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A Quantitative Assessment of the Effectiveness of a Global Online Professional
Development Course to Enhance 21st Century Skills in STEM Instructional Design

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A Dissertation submitted to The Graduate School at the University of Missouri-St. Louis
in partial fulfillment of the requirements for the degree
Doctor of Philosophy in Education with emphasis in Teaching and Learning Processes

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ABSTRACT

Science, technology, engineering and mathematics (STEM) disciplines are becoming increasingly important in the 21st century workforce, but there is currently a shortage of STEM professionals around the world. Even when students graduate with STEM degrees, many lack basic interpersonal skills such as communication and problem solving that would position them for success in the marketplace. The New York Academy of Science developed the STEM Education Framework to help ensure that STEM curricula teach the Essential Skills that students need in order to thrive in the modern workplace. In order for educators to proficiently utilize the STEM Education Framework, they must receive training on its use through professional development.

STEM Education in the 21st Century is a ten-week online professional development course dedicated to supporting K-12 educators as they apply the STEM Education Framework to improve their STEM instruction. Data were collected from a global sample of STEM educators who completed the course in the fall of 2019. A quantitative descriptive study with a causal-comparative design was used to explore the relationships of participant demographics, self-efficacy, and perceived usefulness and ease of use on STEM instructional design. STEM instructional design was measured using the STEM Education Framework to evaluate course participants' pre and post STEM instructional design. Self-efficacy was measured by tailoring self-efficacy scales to each of the Essential Skills. Perceived usefulness and ease of use was measured using applicable components of a validated scale for measuring the constructs. While one-way analysis of covariance (ANCOVA) yielded no statistically significant results among demographics, self-efficacy, perceived usefulness and ease of use and STEM

instructional design with the exception of nationality and STEM instructional design, change between pre- and post-STEM instructional design scores indicate that participants improved throughout the course.

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LIST OF ACRONYMS

LMS – Learning Management System

OPD – Online Professional Development

PD – Professional Development

SEC – STEM Education in the 21st Century

STEM – Science, Technology, Engineering, Mathematics

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This dissertation is dedicated to my children, Theo and Ava. This is a goal I set for myself a long time ago. It has been a hard journey. I started it three different times.

Persistence, by definition, involves difficulty. But it is easier to persist and chase our goals when we have loved ones in our corner – your silliness, laughter, and hugs have given me strength in my corner – no matter what you choose in life, mom and I will always be in yours.

CHAPTER 1

INTRODUCTION

In 2001, Judith Ramaley, then the assistant director of education and human resources at the National Science Foundation, introduced the acronym STEM to the national conversation (Christenson, 2011). Since then, STEM, the combined disciplines of Science, Technology, Engineering, and Math, has grown in esteem, and this joint discipline can be found in schools across the globe. STEM education provides students with opportunities to develop the necessary competencies, in addition to content knowledge, that are needed to be successful in a rapidly evolving job-market. STEM education gives students a chance to learn that the world is interconnected rather than isolated into specific content areas (Dugger, 2010). When rote learning and memorization are emphasized in STEM subjects, graduates often struggle to apply learned concepts to the real-life challenges they face in the workplace (Kramer et al., 2014). Students often graduate without complementary fundamental skills in critical thinking, problem solving, creativity, communication, collaboration, data literacy, and digital literacy and computer science that are necessary for successful employment. Contemporary STEM education should go beyond piecemeal content knowledge and provide students with learning experiences where they have opportunity to develop essential skills. Holmes et al. argued that STEM education that prepares students with 21st Century skills will influence the percentage of students who declare a STEM major in college and go on to pursue STEM careers (2017).

STEM educators must have extensive knowledge in highly technical fields that are constantly evolving while simultaneously empowering students to learn skills to

apply their knowledge to unique, real-world scenarios. In order to effectively educate in K-12 STEM classrooms, educators must be, as Shulman (1986) identifies, skilled in the art of blending content and pedagogy so that instruction is adapted to the diverse interests and abilities of learners.

One of the most important in-school factors determining student achievement is teacher quality (George et al., 2005). A powerful way to improve education is to provide educators with professional development (PD) in research-based instructional methods (Darling-Hammond, 2009). Additionally, teachers' high sense of self-efficacy has been a well-documented attribute of effective teachers (Henson et al., 2001). A high sense of self-efficacy in teachers has impact on teacher- and student-related educational outcomes such as teachers' instructional behavior, persistence, commitment, and enthusiasm, and student motivation, self-efficacy beliefs, and achievement (Tschannen-Moran & Hoy, 2001).

The traditional method of training educators is through PD courses and workshops. In traditional PD format, a perceived expert shares knowledge or strategies as educators sit through a lecture-style workshop that ranges from one hour to multiple days or weeks. Traditional PD is widely criticized as being ineffective (Bereiter, 2002; Darling-Hammond, Holtzman, Gatlin, & Heilig, 2005; Diaz-Maggioli, 2004; Garet, Porter, Desimone, Birman, & Yoon, 2001; Guskey & Sparks, 1991; Scotchmer, McGrath, & Coder, 2005). Traditional PD does not provide teachers sufficient time (Borko, 2004; Dede, 2006; Diaz-Maggioli, 2004; Guskey, 2002; Hargreaves & Fullan, 1992; Summerville & Johnson, 2006), content (Ferguson & T. Womack, 1993; Garet et al., 2001), or activities to provide knowledge of critical concepts and meaningful change in

practice (Hargreaves, & Fullan, 1996; Loucks-Horsley, Hewson, Love, & Stiles, 1998). Furthermore, to attend traditional PD experiences, teachers are generally required to take time off of work, meaning time out of their classrooms, to attend sessions, which may have additional negative outcomes for students. Thus, teachers, in their attempt to improve their instructional ability, must leave their students behind as they attend, what is likely to be, an ineffective PD experience.

The availability and use of computerized programs for teacher PD is rapidly expanding (Appana, 2008). Online professional development (OPD) removes the barrier of time constraints and allows educators to participate at their convenience. Further, rather than traditional one-day workshops, OPD gives educators extended time for reflection, application, and discussion with like-minded peers (Dede et al., 2009). Because of affordability and accessibility of OPD, it is becoming a more popular choice for PD among schools and teachers (Fisher et al., 2010; A. Holmes et al., 2011).

Education in STEM fields reflects rapidly changing knowledge, therefore, teachers must continue to enhance their own knowledge as well as their pedagogical approach. Furthermore, while teachers may know about 21st Century skills and may want to integrate them into their instruction, no generally accepted standard for their inclusion in instruction exists. This results in teachers learning about and taking a fragmented approach to including 21st Century Skills. “To help young people learn the more complex and analytical skills they need for the 21st Century, teachers must learn to teach in ways that develop higher-order thinking and performance” (Darling-Hammond & Richardson, 2009). According to Guskey (2003), successful PD deepens educators’ understanding of content and supports their attempts to help students learn the content.

The STEM Education Framework (New York Academy of Sciences, 2016) was constructed to support curriculum developers integrate 21st Century skills into K-12 STEM instructional programs. The STEM Education Framework identifies best practices in STEM education. Intended to be used by curriculum developers, teachers, and school leaders, the framework identifies 26 elements of quality STEM education in 3 essential areas:

- Core Competencies: To what extent are students provided with opportunities to develop 21st Century skills needed to thrive in the modern workplace?
- Instructional Design: To what extent do instructional materials and/or program design reflect research-based pedagogy and a cohesive system of learning objectives, supports, and assessment resources?
- Implementation: To what extent are necessary supports or services available to facilitate distribution and ensure effective implementation?

Using the STEM Education Framework, STEM curricula can be evaluated according to each of the 26 elements by using the holistic rubric that accompanies each element. Each of the holistic rubrics detail research-based criteria for meeting one of four proficiency levels: Exemplary, Developing, Basic, and Undeveloped.

Purpose

STEM careers are becoming increasingly prominent (Bughin et al., 2019) yet, it has been identified that, while more people are graduating with STEM degrees, many STEM positions are going unfilled because many STEM graduates lack the complementary fundamental skills of critical thinking, problem solving, creativity,

communication, and collaboration necessary for successful employment (Kramer et al., 2014). It is generally accepted that the purpose of education is to equip people with the skills and knowledge to be productive citizens. Therefore, teachers need support to be able to equip students with the Essential Skills. Given the nature of demands on educators, online courses present a cost and time effective method of supporting educators' improvement.

The purpose of this quantitative descriptive study with causal-comparative design is to describe and evaluate the effectiveness of an OPD that aims to enhance STEM educators' ability to include 21st Century skills in their instructional design.

STEM Education in the 21st Century (SEC) is a ten-week OPD course created by the New York Academy of Sciences for K-12 STEM educators. The SEC aims to support educators as they learn how to apply the STEM Education Framework to their own instruction. The driving theory behind the SEC is, if educators understand how to use the STEM Education Framework to improve the integration of 21st Century skills into their STEM instruction, then they will in fact use it, and then their students will have improved opportunities to develop 21st Century skills, namely: critical thinking, problem solving, creativity, communication, collaboration, data literacy, and digital literacy & computer science. The STEM Education Framework collectively refers to these seven 21st Century skills as the Essential Skills. The SEC is an asynchronous course in which educators a) learn the research that supports the STEM Education Framework as well as the research that supports the need for students to be competent in each essential skill, b) learn how to apply the STEM Education Framework to their own instruction so that their students

have improved opportunities to develop the essential skills, c) collaborate with peers over instructional strategies.

Research Questions

To understand if the SEC has meaningful impact on participants' understanding and perception of the STEM Education Framework and, therefore, impact on their inclusion of 21st Century skills in their regular STEM instruction, the following research questions will be addressed:

1. Is there a statistically significant difference in SEC participants' post STEM instructional design mean scores and participants' demographics (age, gender, years of teaching experience, and nationality), controlling for pre STEM instructional design mean scores?
2. Is there a relationship between SEC participants' demographics and self-efficacy mean scores on post STEM instructional design mean scores?
3. Is there a relationship between SEC participants' demographics and perceived usefulness and ease of use mean scores on post STEM instructional design mean scores?

Null Hypotheses

H_0 1: Participants' demographics will have no influence on instructional improvement controlling for initial instructional mean scores.

H_0 2: Participants' demographics will have no influence on the relationship between self-efficacy and post STEM instructional design mean scores, controlling for initial instructional means scores.

H₀ 3: Participants' demographics will have no influence on the relationship between perceived usefulness and ease of use and post STEM instructional design mean scores, controlling for initial instructional evidence.

Population

Participation in the SEC is limited to 100 applicants who identify themselves as K-12 classroom teachers of one or more STEM content areas. Participants will be limited to teachers whose primary language is English. While the SEC will be advertised to educators on a global scale, it is expected that the majority of participants will be located in the greater New York City area for two reasons: a) the New York Academy of Sciences is established in New York City and, as a result, has a high percentage of members and an easier ability to market in the New York City area; b) the New York Academy of Sciences is able to provide New York teachers who successfully complete the SEC with Continuing Teacher and Leader Education credits, which teachers in New York need in order to maintain their teaching licensure.

Delivery Methodology

STEM Education in the 21st Century (SEC) is a ten-week course delivered exclusively via an online learning management system (LMS). Participants of the SEC must be able to access the Internet, the application website, the LMS website, and additional text formatting software (i.e. Microsoft Word, Google Docs).

Evaluation Metrics

Stanford Research International (Stanford Research Institution - Education Division, 2016) and a board of international advisors of a global non-profit organization based in the state of New York created the STEM Education Framework (2016). The STEM Education Framework is a research-based tool and served as the guide for the development of the SEC as well as the evaluation metric, or scoring guide, used to evaluate the SEC participants' initial and final projects.

Definitions of Terms

- 21st Century Skills – “A broad set of knowledge, skills, work habits, and character traits that are believed—by educators, school reformers, college professors, employers, and others—to be critically important to success in today’s world, particularly in collegiate programs and contemporary careers and workplaces” (“21st Century Skills,” n.d.).
- Core Competencies – A specific list of 21st Century skills needed for students to thrive in the modern workplace. Core Competencies are broken into two categories, Essential Skills and Supporting Attributes, in the STEM Education Framework (2016) with Essential Skills being the focus in the SEC.
- Essential Skills – Seven “competencies that, in addition to content knowledge, students must develop to thrive in the modern workplace” (New York Academy of Sciences, 2016). These competencies are identified in the STEM Education Framework as critical thinking, problem solving, creativity, communication, collaboration, data literacy, and digital literacy and computer science .

- Online Professional Development (OPD) - Any digital professional development that takes place partially or completely over the Internet (Fishman et al., 2013).
- Professional Development (PD) – Activities that are intended to engage professionals in new learning about their professional practice (Knapp, 2003).
- Self-Efficacy – The “beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments” (Bandura, 1997).
- STEM - The disciplines of science, technology, engineering, and math.
- STEM Education Framework – A series of holistic rubrics that can be used to evaluate the degree to which STEM curricula give K-12 students opportunities to develop 21st Century skills. Curricula can be evaluated as “Exemplary”, “Developing”, “Basic”, or “Undeveloped” for each skill respective of the criteria the curricula meet for each skill. The STEM Education Framework was developed by the New York Academy of Sciences (2016) with support from an international board of advisors.
- STEM Education in the 21st Century (SEC) – A ten-week online course in which K-12 STEM educators learn about the STEM Education Framework and revise an instructional unit so that it provides participants’ students with opportunities to develop the Essential Skills.
- Traditional Professional Development - A structured methodology of professional development in which a person(s) with specific expertise presents to participants who attend sessions at scheduled times. Examples of traditional PD include workshops, educational institutes, graduate courses, learning seminars, and teachers’ conferences (Garet et al., 2001).

Significance of Study

STEM has become a known discipline in education and it is becoming increasingly accepted that young people will need 21st Century skills, in addition to content knowledge, to be successful in modern careers. While national and local standards of STEM teaching and learning exist, no standard for inclusion of 21st Century skills in STEM education has been accepted. This study is significant because it analyzes the SEC, an online course that supports K-12 STEM educators learn how to apply a framework that is designed to help them improve their students' opportunities to develop critical 21st Century skills. Given the current COVID-19 pandemic, quality online PD is increasingly needed to provide teachers with resources to improve their teaching while maintaining social distance. As organizations and individuals develop and deploy OPD, they will need to market their OPD offerings as efficiently as possible. Examining demographic data as they pertain to the effectiveness of SEC will provide guidance on future marketing efforts by potentially narrowing the scope of relevant users.

Summary

It is imperative that students have access to high-quality STEM education that supports their development of Essential Skills as identified in the STEM Education Framework. In the next ten years, due to automation in the workplace, STEM professionals are projected to have the second highest employment growth; health professionals, which is also a critical STEM career, is projected to lead all career fields in employment growth (Bughin et al., 2019). In order to equip students with the necessary knowledge and skills to succeed in modern careers, we must support teachers with the

appropriate instructional tools so they can effectively prepare the future workforce.

Lawless & Pellegrino (2007) identify PD as a standard method for educators to improve their instructional practices and make an easier shift to addressing the new educational needs (Garet et al., 2001) of 21st Century skills. The STEM Education Framework provides guidance for educators who want to make the shift to incorporating 21st Century skills in their STEM instruction.

Professional development for K-12 STEM teachers is a commonly accepted way for teachers to continue to build their pedagogical and content knowledge. Much research identifies that PD opportunities for teachers provide inadequate content and are inefficient with time. It is important to know if effective PD can be delivered to STEM teachers in a completely online environment that respects their busy and important lifestyles.

CHAPTER 2

REVIEW OF LITERATURE

First, historical and current delivery methodologies for professional development (PD) for educators will be explored. Then, 21st Century skills will be discussed to further understand what PD is needed to equip STEM educators with relevant skills. Finally, research will be reported on the theoretical framework for STEM Education in the 21st Century (SEC) and evaluation methodology to explore the research questions.

Research Questions

To understand if the SEC has meaningful impact on participants' understanding and perception of the STEM Education Framework and, therefore, impact on their inclusion of 21st Century skills in their regular STEM instruction, the following research questions will be addressed:

1. Is there a statistically significant difference in SEC participants' post STEM instructional design mean scores and participants' demographics (age, gender, years of teaching experience, and nationality), controlling for pre STEM instructional design mean scores?
2. Is there a relationship between SEC participants' demographics and self-efficacy mean scores on post STEM instructional design mean scores?
3. Is there a relationship between SEC participants' demographics and perceived usefulness and ease of use mean scores on post STEM instructional design mean scores?

In order to address these research questions, one-way analysis of covariance (ANCOVA) and linear regression models will be used to analyze the associations of demographic variables, self-efficacy scores, and perceived ease of use and usefulness for participants' STEM instructional design.

Importance of and Need for Teacher Professional Development

Researchers, policymakers, educators and parents agree that one of the most important in-school factors determining student achievement is teacher quality (George et al., 2005; Kleiman, 2004); therefore, developing successful teachers is critical (Marzano, 2006). Students' measured academic achievement grows with the number of years they work with effective teachers (Kaplan & Owings, 2004). Teacher knowledge and practices have been found to improve as a result of PD (Lawless & Pellegrino, 2007; Stewart, 2014). Continuous PD is the most effective strategy to ensure continued improvement (Mcleskey & Waldron, 2002). Professional development is a fundamental approach to improve educators' knowledge and skills (Elmore, 2002). The purpose of PD is have a positive impact on student learning and achievement by making positive impacts on teachers' behaviors (Darling-Hammond et al., 2009).

History and Types of Professional Development

One time, one shot in-service workshops that brought teachers together for short lectures were the most frequent PD experiences for teachers in the 20th Century (Lieberman, 1995). Traditional PD is typically delivered from outside sources (The National Academies of Sciences, Engineering, and Medicine, 2015) and offered in a sit, listen, and absorb approach (McLeskey & Waldron, 2002). In these one-time-workshops

(Nishimura, 2014), an expert presents information on a topic (Desimone, 2009) and participants take learned concepts back to their classrooms and implement it independently (McLeskey & Waldron, 2002). This method of PD has not been found to have lasting impacts on teacher performance or student outcomes (Nishimura, 2014).

In 2001, Garet et al. described three integral components of effective PD: (1) PD should be collaborative with active participation, (2) PD should take place over an extended period of time with continuous interaction, (3) PD activities should be relevant to everyday teaching settings. Further research identifies additional components of effective PD, such as a focus on active learning activities, an application to educators' classroom practices, and content-driven experiences (Archibald et al., 2011; Borko, 2004; Darling-Hammond & Bransford, 2005; Desimone et al., 2002; Elmore, 2002; Kedzior, 2004; Lieberman & Pointer-Mace, 2009).

Effective Professional Development

Teachers must be provided opportunity to develop the required knowledge and skills in order to improve their instructional abilities (Reeves, 2012). A high standard of evidence is required to ensure that teachers are receiving quality PD (Guskey & Sparks, 2000). Professional development delivered over an extended period time gives educators increased opportunity for in-depth peer-peer discussion of content and pedagogical approaches (Birman et al., 2000; Garet et al., 2001). Properly developed OPD can give educators high-quality knowledge and skills over a sustained period of time while meeting educators' busy schedules.

Through a national sample of over 1,000 surveyed teachers, Garet et al. (2001) found that form, duration and participation were reported to have high impact on teacher

reported outcomes of PD. PD activities that take an active and collaborative form have positive impact on teacher knowledge (Garet et al., 2001), particularly those in which the active engagement centers around curriculum planning (Lieberman, 1995; Loucks-Horsley et al., 1998). Nishimura (2014) found that PD that takes place over longer periods of time makes positive impacts on teachers' instructional abilities and student outcomes. Participation in content-driven PD in which educators build on their own content knowledge and that which is grounded in teachers' daily practices have also been shown to improve student achievement (Darling-Hammond & McLaughlin, 1995; Hirsh, 2005; Joyce & Showers, 2002). Based on this research, the SEC was developed a.) to be delivered over ten weeks b.) to have participants actively collaborate with peers via weekly written discussion boards c.) to have participants develop instruction that incorporates the criteria in the STEM Education Framework and d.) to have participants develop instructional practices that can be integrated easily into daily teaching.

Online Professional Development

Online professional development (OPD) is the process of engaging educators, either partially or completely over the Internet, in learning activities that are designed to improve their knowledge of professional practice (Fishman et al., 2013; Kleiman, 2004). OPD can be delivered through a variety of formats including facilitated and self-paced courses, massive online open courses (MOOCs), and certificate programs (Dash et al., 2010; Hew & Hara, 2007; Marrero et al., 2010; Reese, 2010; Vivian et al., 2014). Online learning is increasingly chosen by educators as an avenue for PD because it allows educators to participate at times that are personally convenient at more affordable costs (Fisher et al., 2010; A. Holmes et al., 2011), has the benefits of ongoing, real-time

support (Dede et al., 2009), and places participants within communities of people who are interested in improving their learning in similar content areas (Lave & Wenger, 1991).

Online professional development (OPD) has many potential benefits for teachers, schools, districts, states, for-profit, and non-profit organizations. According to a 2007 report from the National Research Council, potential benefits of OPD as identified by teachers themselves include:

- Flexibility and versatility – OPD can take many forms and adds convenience, and scalability when compared with the one-time face-to-face workshops.
- Potential to build community among teachers and across groups – OPD allows teachers to interact with each other in real time or asynchronously, offering them time to think deeper on a subject before responding to an ongoing exchange.
- New possibilities for accountability – Online course facilitators can easily track participation and contribution of each participant.

OPD can be scaled to reach an increasing number of teachers in an increasing number of locations around the globe. No longer are organizations limited to serving teachers in the organization's immediate community. Because the Internet is nearly ubiquitous, OPD can support teachers in low-, medium-, and high-resourced urban, suburban, and rural communities. High-quality OPD could be a major step in leveling the playing field among schools in this spectrum of communities. While creating OPD has a high initial cost of development, sustaining online courses over time has low budgetary implications. The initial cost of development can be amortized across the number of

times the same course is offered, essentially meaning that courses pay for themselves after a finite number of times being offered. The bulk of the cost then becomes paying a fee for the Learning Management System upon which the course is hosted and the cost of course facilitators.

Dede et al. (2009), describes a research agenda that focuses of five key areas of OPD. These areas were applied to SEC as a guide to program planning and enrichment. First, in order to ensure program goals are met, OPD must be evaluated using empirical data. Second, outcomes of OPD such as participation and satisfaction must be measured for effectiveness. Third, research on the delivery within, and the design of the LMS must be conducted to gauge its impact on teachers' learning. Fourth, research on OPD instructors' online discourse with participants should be conducted to understand the support structures in place for participants. Fifth, OPD should ensure that participants receive real-time, ongoing support that accommodates their busy schedules. The SEC applied these five principles to develop a course to enhance participants' experience and learning.

STEM Education and 21st Century Skills

STEM education can be described as the formal teaching and learning in the STEM fields of science, technology, engineering, and mathematics (Gonzalez & Kuenzi, 2012). In some reports STEM emphasizes only one discipline, whereas in other reports, two or more, or even all four disciplines must be integrated to be considered STEM (Breiner et al., 2012; Brown & Borrego, 2013). In either case, STEM education can be defined as a compilation of instructional strategies that enable students to apply content knowledge to solve problems using engineering and scientific methods, including

multiple and diverse technologies (Bybee, 2010b). Benefits of STEM education include increases in several measures of academic achievement, students interested in STEM disciplines, and students who choose STEM majors (Moorehead & Grillo, 2013; Zuger, 2012) as well as increases in people ultimately choosing STEM careers (Buckley, 2009). STEM education has also been shown to have a positive impact on students' development of 21st Century Skills (Becker & Park, 2011; National Research Council, 2011).

It is necessary for students to be well-versed in 21st Century skills to ensure they are globally competitive in the workplace (Atkinson, 2012; Breiner et al., 2012; Crippen & Archambault, 2012). Learning and innovating skills, such as critical thinking, problem solving, communication and collaboration, are increasingly recognized for better preparing students for more complex life and work environments in the 21st Century (P21, 2015). Students must master 21st Century themes in addition to key subjects (Parsons & Beauchamp, 2012), therefore, schools must promote an understanding of academic content by weaving 21st Century interdisciplinary themes into key subjects (P21, 2019). Increasing students' competencies in 21st Century skills, along with content knowledge, means students know *how* to think, not just *what* to think (Prettyman et al., 2012).

All STEM disciplines present opportunities for building students' 21st Century skills (Bybee, 2010a; Prettyman et al., 2012). Beers (2011) describes three natural matches between STEM education and 21st Century Skills: 1) through STEM learning, students have an opportunity to grapple with real-life problems that are engaging and relevant; 2) while exploring real-life problems, students apply content knowledge in

innovative ways in which they must access, analyze, and use the information they need to complete the learning tasks; 3) STEM education allows students to manage time, become self-directed learners, and collaborate with others, which are important life and career skills.

STEM Education Framework

In 2014, the New York Academy of Sciences published a white paper that articulated that, while there are greater numbers of college graduates in STEM disciplines worldwide than ever before, STEM jobs remain unfilled (Kramer et al., 2014). The white paper identified one of the underlying causes of this paradox as a shortage of graduates with fundamental skills such as communication, critical thinking, and teamwork (Kramer et al., 2014). This white paper prompted the New York Academy of Sciences to conduct further research on what fundamental skills are necessary for success in the modern workplace and how to effectively insert opportunities for students to develop these skills into K-12 education. Upon conclusion of this research, the New York Academy of Sciences published the STEM Education Framework Research Foundations (Stanford Research Institution - Education Division, 2016) which identified the Essential Skills and Supporting Attributes that students must possess and the Instructional Design Principles and Implementation Supports necessary to effectively embed the Essential Skills into STEM instruction. The STEM Education Framework Research Foundations is the bedrock upon which the STEM Education Framework is designed. As mentioned in chapter one, the STEM Education Framework is a series of holistic rubrics that guide curriculum developers, teachers, and administrators on developing or evaluating STEM curricula that provide students opportunities to develop the 21st Century skills. The SEC

was designed to support classroom educators implement the STEM Education Framework within their own curriculum or lesson development.

Theoretical Framework

STEM Education in the 21st Century was developed using several theories of human learning. Learning is an active process of building knowledge (Mascolo et al., 2005) and is constructed within a variety of contexts and personal experiences (K. Holmes et al., 2017). Bandura (1986) claimed that learning occurs when the learner has a sufficient belief in their capabilities and skills. Throughout the SEC, participants completed surveys in which they reported their perceptions of self-efficacy related to course content. The implementation of directed discussion threads in OPD is based on Vygotsky's (1978) sociocultural theory of human learning because it emphasizes the critical role of social interaction in learning. The SEC required that participants engage each other via written discussion threads that were monitored by course facilitators. Much research about maintaining participants' interest in online courses stems from Bruner's (1966) theory that learning occurs when participants actively participate in intentionally designed learning. Further, Dewey (1938) emphasized the need to learn by doing. Applying the theories by Bruner and Dewey, the SEC required that participants actively develop units of instruction that applied the content being explored. Forrest and Peterson (2006) describe Knowles' (1984) learning theory, Andragogy, as having four primary assumptions. The SEC applied these four principles of adult learners:

1. Adults are self-directed learners: As participants of the SEC completed assignments, they did so upon choosing their own process and product for each assignment.

2. Adults bring their own knowledge and experience to the learning process:

Participants of the SEC were required to have been a teacher for at least one year prior to taking the course. This gave all participants a minimum requirement of experience upon which they could build additional knowledge and skills.

3. Adults come to the learning process ready to learn: Participation in SEC was completely voluntary. Participants were intrinsically motivated to enroll and complete the course and did so because they were interested in integrating 21st Century skills into their STEM instruction.

4. Adults are oriented toward immediate application of learned knowledge:

Weekly assignments and the final project of SEC required that participants develop an instructional unit that they could immediately deploy within their own K-12 STEM classrooms.

Assessment and Evaluation of Professional Development

STEM Education in the 21st Century (SEC) used three methods to assess and evaluate participants' instructional improvement and associated variables: (a) the STEM Education Framework (New York Academy of Sciences, 2016), (b) Bandura's (1977) theory of self-efficacy, and (c) perceived usefulness and perceived ease of use as described by Davis (1989).

Teacher Self-Efficacy

The concept of self-efficacy emerged from Bandura's (1977) social cognitive theory and presents a dynamic perspective that accounts for one's capacity to exercise

control through intentionality of actions. Teachers' beliefs in their ability to teach and impact student learning is connected to social cognitive theory (Tschannen-Moran & Hoy, 2001; Woolfolk et al., 1990). Self-efficacy impacts one's ability to complete a task because it relates to the amount of effort required to complete the task (Bandura, 2010; Pajares & Schunk, 2001). Teacher self-efficacy is an influential factor on teacher effectiveness (Bitto & Butler, 2010) and can be positively related to increased student achievement, motivation, and self-efficacy (Anderson et al., 1988; Caprara et al., 2006; Tschannen-Moran & Hoy, 2001)

Given the relationship between self-efficacy and the belief in one's ability to successfully accomplish a task, Bandura (2001) suggests that teachers with high self-efficacy may have more resilience than teachers with low self-efficacy. Ghaith and Yaghi (1997) found that teachers who reported high self-efficacy resulted in a higher percentage of PD goals achieved, as well as a continued use of materials and methods gained in the PD.

Self-efficacy is linked to distinct realms of functioning (Bandura, 2006) therefore there is no all-purpose measure for perceived self-efficacy (Choi et al., 2013). Self-efficacy scales must be developed to address specific constructs. Scale items should be phrased in terms of *can do* because *can* is a judgement of capability rather than intention (Bandura, 2006). Self-efficacy survey items should require that individuals rate the strength of their belief in their ability to execute specific activities (Bandura, 2006). While Bandura (2006) cites reliability of data using a 10-point scale, where individuals record the strength of their efficacy beliefs from 0 ("Cannot do"); through intermediate degrees of assurance, 5 ("Moderately certain can do"); to complete

assurance,¹⁰ (“Highly certain can do”), he also notes that people tend to avoid the extreme positions on a scale. Thus a 100-point efficacy scale, with the same anchors, will report a stronger predictor of performance than one with a 10-interval scale (Pajares et al., 2001).

Perceived Usefulness and Perceived Ease of Use

STEM Education in the 21st Century (SEC) was developed to improve educators’ ability to create STEM units of instruction that give participants’ students opportunities to develop 21st Century skills. Alavi and Henderson (1981) note that if users do not perceive an application as useful, even if it would objectively improve performance, they would be unlikely to use it. In order to understand whether SEC has ecological validity, and therefore, real-world application to STEM educators’ work habits, two constructs, perceived usefulness and perceived ease of use, are explored. Perceived usefulness is defined as “the degree to which a person believes that using a particular system would enhance his or her job performance” while perceived ease of use is defined as “the degree to which a person believes that using a particular system would be free of effort” (Davis, 1989). According to Davis (1989), perceived ease of use is supported by Bandura's (1982) research on self-efficacy because Bandura’s description of being able to successfully accomplish an outcome is similar to perceived usefulness.

Both perceived usefulness and ease of use have been found to exhibit significant empirical relationships with self-reported measures of usage behavior (Davis, 1989). Ease of use has been shown to be an antecedent to usefulness which, in turn, is an antecedent to usage (Davis, 1989). Meaning that research shows an ease of use → usefulness → usage chain of causality (Radner & Rothschild, 1975). Therefore, if participants report,

upon completing SEC, high perceived usefulness and ease of use of the STEM Education Framework, it can be expected that they will continue to use the STEM Education Framework to influence their instruction.

Summary

Companies need a workforce that has 21st Century skills so they can deal with unknown challenges and quickly move products to market and compete with global competition (National Research Council, 2010). In order to prepare the future workforce, K-12 STEM educators must be equipped with the skills and knowledge to give students opportunities to develop their own 21st Century skills. In order to equip educators with the skills and knowledge, high quality PD that meets the demands and limitations of STEM teachers must be widely available.

CHAPTER 3

METHODOLOGY

To evaluate the online professional development program, STEM Education in the 21st Century (SEC), a quantitative descriptive study with causal-comparative design was utilized. The evaluation focused on exploring the effects of demographics on STEM instructional design, self-efficacy to implement the STEM Education Framework, and perceived ease of use and usefulness of the STEM Education Framework (2016). The following is a discussion of the research design, research questions, hypotheses, population and sample, methods of data collection, ethics and human relations, data analysis procedures, and limitations.

Research Design

A quantitative descriptive study with a causal-comparative design, also known as ex post facto research, is employed to explore the relationship among SEC participants' demographics, self-efficacy, and perceived usefulness and ease of use for STEM instructional design. A causal-comparative design allows investigators to find relationships between independent and dependent variables after an action or event has already occurred (Brewer & Kuhn, 2010). Kerlinger (1966) defined ex post facto research as that where the researcher starts with the observation of a dependent variable and then studies independent variables, in retrospect, for their possible relationship with the dependent variable. The SEC was completed prior to data analysis; therefore, all data is already collected and no variables will be experimentally manipulated. In alignment with Kerlinger, the goal of SEC was to have an impact on participants' STEM instructional

ability (dependent variable). The independent variables demographics (age, gender, years of teaching experience, and nationality), self-efficacy, and perceived usefulness and ease of use will be studied for their relationships with STEM instructional ability.

Research Questions

Based on the data collected from the SEC, three research questions were designed:

1. Is there a statistically significant difference in SEC participants' post STEM instructional design mean scores and participants' demographics (age, gender, years of teaching experience, and nationality), controlling for pre STEM instructional design mean scores?
2. Is there a relationship between SEC participants' demographics and self-efficacy mean scores on post STEM instructional design mean scores?
3. Is there a relationship between SEC participants' demographics and perceived usefulness and ease of use mean scores on post STEM instructional design mean scores?

Population and Sample

The participant population includes international K-12 STEM educators who participate in online professional learning and are able to effectively communicate in English. SEC was marketed to potential participants via email and social media methods. Additionally, SEC was advertised on the New York Academy of Sciences' website and was open to all K-12 STEM educators who were able to effectively communicate in English but was limited to the first 100 participants who registered. Participants were informed that SEC would be free of charge and that future sessions of SEC would cost

participants an undetermined amount. It was advertised that participants from New York State who successfully complete SEC would be able to earn Continuing Teacher and Leader Education credits to maintain their teaching licensure. Nearly 400 people started the online application; 101 submitted applications by the deadline. Of the 101 applicants, 97 were accepted into the SEC. Four applicants were not granted access to the SEC for the following reasons: One applicant did not already have a unit of instruction to revise (this applicant was a first-year teacher with no previously developed instructional units), another did not have the ability to effectively communicate in English as determined by a follow up email. Two applicants did not fulfil the required upload of an instructional unit. These applicants uploaded videos instead of instructional units.

Participants were enrolled through an online learning management system (LMS) once they were selected and notified of acceptance. A program manager enrolled each participant individually using that participant's name and personal information that was collected during the application process. Prior to the SEC, participants were provided a syllabus with a general overview, a list of objectives, and the sequence of materials. See Appendix B for the syllabus.

Methods of Data Collection

Three instruments were used to collect data. SurveyMonkey Apply was used to collect self-reported participant demographics prior to the SEC. Participants submitted initial and final STEM instructional units via the LMS that was used to administer the SEC. Course facilitators evaluated participants' initial and final STEM instructional unit submissions for STEM instructional ability using the STEM Education Framework (New

York Academy of Sciences, 2016). SurveyMonkey was used to collect participants' self-efficacy (Bandura, 1977) and perceived usefulness and ease of use (Davis, 1989).

Measures

Three measures were collected throughout the SEC. Prior to the launch of SEC, participants' demographics were collected via SurveyMonkey Apply. Participants' STEM instructional ability was collected via the LMS at the onset and at the end of SEC. Self-efficacy was collected throughout SEC and perceived usefulness and ease of use was collected at the end of SEC, each via SurveyMonkey. Table 1 displays the timeline of data collection for each measure.

Table 1

Timeline of Data Collection

Measure	Method of Collection	Initial Collection	Final Collection
Demographics (Age, Years of Teaching Experience, Gender, Nationality)	Survey Monkey Apply	Prior to SEC	NA
STEM Instructional Design	LMS	Week 1	Week 10
Self-Efficacy	SurveyMonkey		
Critical Thinking		Week 2	NA
Problem Solving		Week 3	NA
Creativity		Week 4	NA
Communication		Week 5	NA
Collaboration		Week 6	NA
Data Literacy		Week 7	NA
Digital Literacy & Computer Science		Week 8	NA
Perceived Usefulness and Ease of Use	SurveyMonkey	Week 10	NA

Demographics

Demographic data was collected prior to SEC via SurveyMonkey Apply and was required of all applicants as part of the application process. To ensure validity of data, applicants were informed that their responses would have no impact on their acceptance. Demographics included: a) age, which was collected in the following categories: 21 – 25, 26 – 30, 31 – 35, 36 – 40, 41 – 45, 46 – 50, 51 – 55, 56 – 60, and 61+; b) years of teaching experience, which was collected in the following categories: 1 – 5, 6 – 10, 11 – 20, and 21+; c) gender, which was collected in the following categories: Male, Female, and Other; and d) nationality, which was collected by asking participants to type their country of residence into a text field. Nationality was categorized as participants who reside in the United States of America (US) and Non-US participants. While race is typically included as demographic data in many studies, it was excluded because it was not collected throughout SEC. Developers of SEC determined that since SEC was offered globally, nationality would be sufficient.

See Table 2 for demographic information. The sample consisted of 45 K-12 STEM educators. The range of participant ages included participants in their early twenties to those in their sixties. One participant (2.2%) was aged 21-25, two (4.4%) were aged 26-30, nine (20%) were aged 31-35, thirteen (28.9%) were aged 36-40, five (11.1%) were aged 41-45, five (11.1%) were aged 46-50, six (13.3%) were aged 51-55, and four (8.9%) were aged 56-60. Participants were primarily female (64.4%). Five participants (11.1%) were in their first five years of teaching, 15 (33.3%) in years 6-10, 20 (44.4%) in years 11-20, and 5 (11.1%) had 21+ years of teaching. Of the 45 participants, 21 (46.7%) were from the United States while 24 (53.3%) were foreign.

Table 2

<i>Demographic Data</i>		
Demographic	<i>n</i>	%
Age		
21 – 25	1	2.20
26 – 30	2	4.40
31 – 35	9	20.00
36 – 40	13	28.90
41 – 45	5	11.10
46 – 50	5	11.10
51 – 55	6	13.30
56 – 60	4	8.90
Gender		
Male	16	35.60
Female	29	64.40
Years of Teaching Experience		
1 – 5	5	11.10
6 – 10	15	33.30
11 – 20	20	44.40
21+	5	11.10
Nationality		
US	21	46.70
Non-US	24	53.30

Pre/Post STEM Instructional Design

The STEM Education Framework (2016) is a series of holistic rubrics designed to evaluate the extent to which a STEM curriculum gives students opportunities to develop 21st Century Skills and was used to measure the SEC participants' pre and post STEM instructional design mean scores. The STEM Education Framework (2016) has 26 elements in total; however, the SEC focused on the first seven elements that are

collectively referred to as the Essential Skills. The seven Essential Skills are critical thinking, problem solving, creativity, communication, collaboration, data literacy, and digital literacy & computer science. The holistic rubric criteria for each of the essential skills is categorized into four proficiency levels: Exemplary, Developing, Basic, and Undeveloped. To calculate pre and post STEM instructional design mean scores, each of these proficiencies was assigned a numeric value of 10, 8, 6, and 4, respectively. Each of these four proficiency levels have detailed criteria for meeting the proficiency level and the criteria become more complex and rigorous as proficiency improves from undeveloped to basic to developing, and finally, to exemplary. See Appendix A for the seven holistic rubrics of the Essential Skills of the STEM Education Framework (2016). Content validity of the STEM Education Framework was informed by a literature review that was conducted by the independent non-profit Stanford Research Institute – Education (Stanford Research Institution - Education Division, 2016). Further content validity of the STEM Education Framework was established because it was constructed by an international board of advisors who each have expertise in fields related to its 26 elements.

The researcher and also the primary author of SEC, had no part in evaluating participants' initial or final units. The researcher participated by training facilitators on how to apply the STEM Education Framework (2016) to evaluate STEM curricula. Facilitators were trained on how to evaluate STEM curricular units according to the seven Essential Skills of the STEM Education Framework (2016) through a norming process. Each facilitator was given the same sample instructional unit and asked to evaluate it by assigning a proficiency level of Exemplary, Developing, Basic, or

Undeveloped for each of the seven Essential Skills. Facilitators were also asked to submit written rationale for each of their seven evaluation categories. Upon receiving each facilitators' submission, the researcher led a discussion with all three facilitators by progressing through each of the seven Essential Skills and asking each participant to share their evaluation and rationale. When differences among initial proficiency evaluations existed, facilitators were asked to elaborate on their rationale and were invited to share their rationale for the purpose of agreeing on the same proficiency level before moving to the next Essential Skill. At the end of the meeting, all facilitators agreed on the proficiencies of each of the seven Essential Skills of Unit One. At this point they were instructed to evaluate a second instructional unit, Unit Two, and asked that they apply the level of critique agreed upon and repeat the independent evaluation process. Facilitators' evaluations of Unit Two were unanimous, indicating that facilitators had been effectively normed. See Table 3 for inter-rater reliability ratings.

In addition to evaluating sample instructional units, facilitators were asked to provide written contribution to a sample discussion thread of a related topic. Facilitators were asked to contribute to the discussion thread to enhance the discussion and to respond to a specific person in the discussion. This process allowed the author and primary researcher to determine the quality of feedback that could be expected from each facilitator. Upon reading their responses, the author and researcher determined that all three facilitators gave feedback of similar quality. It should also be noted that this one-time activity is not indicative of the type of quality that a facilitator may give 55+ participants over ten weeks of a course. Therefore, inter-facilitator reliability of feedback is acknowledged as a limitation of data validity.

Table 3*Inter-rater Reliability*

Essential Skill	Rater 1	Rater 2	Rater 3
Initial Rating of Unit One			
Critical Thinking	Basic	Basic	Developing
Problem Solving	Basic	Undeveloped	Basic
Creativity	Undeveloped	Basic	Basic
Communication	Basic	Developing	Basic
Collaboration	Basic	Basic	Basic
Data Literacy	Basic	Undeveloped	Basic
Digital Literacy & Computer Science	Undeveloped	Undeveloped	Basic
Initial Rating of Unit Two			
Critical Thinking	Basic	Basic	Basic
Problem Solving	Undeveloped	Undeveloped	Undeveloped
Creativity	Basic	Basic	Basic
Communication	Developing	Developing	Developing
Collaboration	Developing	Developing	Developing
Data Literacy	Developing	Developing	Developing
Digital Literacy & Computer Science	Exemplary	Exemplary	Exemplary

In week one of SEC, each participant submitted an instructional unit they previously taught in their classrooms. Unit submissions included all instructional artifacts that the participant used to teach the unit, that could include worksheets, videos, slide decks, external websites, lesson plans, scope & sequences, etc. Facilitators evaluated each participant's unit by assigning it a proficiency level of Exemplary, Developing, Basic, or Undeveloped in each of the seven Essential Skills. Proficiencies were then assigned a numeric value of 10, 8, 6, or 4, respectively. Mean pre STEM instructional design scores

were calculated using the assigned numeric values. Participants updated and revised this unit as they progressed through the SEC. In week ten, participants submitted an updated version of the original instructional unit. Participants' updated version included relevant original instructional artifacts as well as instructional artifacts that the participant included for the purpose of improving their proficiency level in each of the seven Essential Skills. After participants submitted their final units, facilitators re-evaluated the unit submissions and calculated mean post STEM instructional design scores through the same process.

Self-Efficacy

Participant self-efficacy data for each Essential Skill was collected via SurveyMonkey at two points throughout SEC: at the end of the week in which participants received the respective content (weeks 2-8), and at the end of SEC. In each survey, participants were emailed the survey using SurveyMonkey's email client. The email included an introductory paragraph that explained that the survey would neither be seen by facilitators, nor affect the course grade of the participants.

Self-efficacy of each Essential Skill was assessed with a unique self-efficacy scale tailored to the criteria identified in the Exemplary proficiency of the respective Essential Skill. Table 4 displays the number of self-efficacy survey items per Essential Skill. To ensure validity of the survey items, Bandura's (2006) Guide to Constructing Self-Efficacy Scales was used to develop questions that address the self-efficacy of each participant for each Essential Skill. In the post-content surveys (weeks 2-8), Bandura's guide was applied while writing questions to assess self-efficacy aligned to individual competencies identified within the exemplary proficiency of each respective Essential

Skill (see Appendix C for survey items). In all surveys, questions began with the phrase, “To what degree can you...” and ended with specific criteria identified within the Exemplary proficiency of the respective Essential Skill.

Table 4

Reliability of Self-Efficacy Scales

Essential Skill	Number of Items in Scale	α
Critical Thinking	7	0.897
Problem Solving	7	0.939
Creativity	5	0.952
Communication	7	0.928
Collaboration	4	0.921
Data Literacy	9	0.96
Digital Literacy & Computer Science	5	0.97

In order to increase reliability of this scale by way of internal consistency, responses to all survey items were captured via a sliding bar where participants record the strength of their efficacy beliefs on a 100-point scale, ranging in single-unit intervals from 0 (“None”); through intermediate degrees of assurance, 50 (“Some”); to complete assurance, 100 (“A Great Deal”) rather than Bandura’s 10-point scale. People usually avoid the extreme positions so a scale with limited response options may, in actual use, shrink to one or two points (Bandura, 2006). Thus an efficacy scale with the 0-100 response format is a stronger predictor of performance than one with a 10-interval scale (Pajares et al., 2001). To ensure internal consistency of the scale, Cronbach’s Alpha was calculated on each of the seven self-efficacy scales. Table 4 displays alpha levels of each self-efficacy scale.

Perceived Usefulness and Ease of Use

Data for perceived ease of use and perceived usefulness was collected at the end of SEC. Survey items to collect this data were included in the final survey along with self-efficacy and additional course-related questions. Survey items were adapted from Davis's (1989) development of valid perceived usefulness and perceived ease of use scales. Six items made up the adapted perceived usefulness and ease of use scale. Three items measured perceived usefulness and three additional items measured perceived ease of use. In alignment with Davis's validated scale, responses to these six items were captured via a seven-point Likert scale with the anchors being "Extremely unlikely" and "Extremely likely". See Appendix C for complete survey items. To ensure internal consistency of the scale, Cronbach's Alpha was calculated on each of the scales as well as the combined scale. Table 5 displays alpha levels of each scale.

Table 5

Reliability of Perceived Usefulness and Perceived Ease of Use Scales

Scale	Number of Items in Scale	α
Perceived Usefulness	3	0.784
Perceived Ease of Use	3	0.855
Perceived Usefulness and Ease of Use (Combined)	6	0.871

Ethics and Human Relations

Three online tools were used to collect data: SurveyMonkey Apply, SurveyMonkey, and Schoology. At the end of SEC, all data, including names and email addresses of participants, were downloaded and stored on the New York Academy of

Sciences' server in compliance with the European Union's General Data Protection Regulation (European Parliament and of the Council, 2016). Prior to accessing the data for analysis, an employee of the New York Academy of Sciences wiped the data of all personally identifying information and gave each participant a unique identifying code. This unique identifying code provided the ability to track participants' data without knowing any personally identifying information about participants. This process ensured that participants' sensitive information is protected in accordance with IRB guidelines.

Data Analysis Procedures

Descriptive statistics were conducted to characterize the variables. For continuous variables, the distribution were reported to determine if the variable violates assumptions of normality.

Data analysis involved examining the relationship among the following independent variables: age, gender, years of teaching experience, nationality, self-efficacy, and perceived usefulness and ease of use, and one dependent variable: STEM instructional design. Evaluations of initial STEM instructional units served as the baseline measure of STEM instructional design and final evaluations of participants' revised STEM instructional units served as the posttest for this dependent variable. Participant results on self-efficacy and perceived usefulness and ease of use surveys served as the measures of their respective dependent variables. See measures section for more details on psychometric properties and scale development procedures on each measure used.

Table 6*Research Models for Analyzing STEM Instructional Design*

Question	Research Question	Statistical Design	Independent Variables	Dependent Variable	Covariate
1	Is there a statistically significant difference in SEC participants' post STEM instructional design mean scores and participants' demographics (age, gender, years of teaching experience, and nationality), controlling for pre STEM instructional design mean scores?	ANCOVA	Gender, Years of Teaching Experience, Nationality, Age	Post STEM Instructional Design	Pre STEM Instructional Design
2	Is there a relationship between SEC participants' demographics and self-efficacy mean scores on post STEM instructional design mean scores?	Linear Regression Model	Gender, Years of Teaching Experience, Nationality, age, Self-Efficacy	Post STEM Instructional Design	N/A
3	Is there a relationship between SEC participants' demographics and perceived usefulness and ease of use mean scores on post STEM instructional design mean scores?	Linear Regression Model	Gender, Years of Teaching Experience, Nationality, age, Perceived Usefulness and Ease of Use	Post STEM Instructional Design	N/A

** post hoc analyses were conducted, when relevant, using Bonferroni correction (Dunn, 1961)

One-way analysis of covariance (ANCOVA) was used to analyze statistical differences in STEM post instructional improvement mean scores with the independent variables of gender, years of teaching experience, and nationality controlling for the covariate of participants' pre STEM instruction mean scores representing baseline achievement in STEM instructional abilities. One-way ANCOVA was used because it assesses the extent to which an independent, categorical variable (gender, age years of

teaching experience, nationality) is associated with a continuous dependent variable (STEM instructional design as measured according to the STEM Education Framework (2016) while controlling for a third covariate variable (initial STEM instructional ability) in order to remove the effect of the covariate on the relationship between the independent and dependent variables (Laerd Statistics, 2018). An analysis of covariance (ANCOVA) was conducted on the sample of participants who completed all aspects of the course ($n = 45$) to assess the impact of age, gender, years of teaching experience, and nationality on instructional improvement, controlling for baseline instructional abilities, to answer question one. Age and years of teaching experience were collected as categorical variables. Nationality was recoded to represent US and non-US participants. If an overall effect is found, post hoc analyses will be conducted to further characterize the relationships of the variables using Bonferroni tests.

Linear regression models were intended to be used to answer questions two and three. For question two, the association of demographic variables and self-efficacy mean scores with post STEM instructional design mean scores was investigated. Post STEM instructional design mean scores were used as the dependent variable, gender, age, years of teaching experience, nationality, and self-efficacy were used as the independent variables. Categorical data (age, years of teaching experience, gender, and nationality) were dummy coded with the first option used as the reference category for each item. Prior to running the linear regression model, correlations between the independent variables and dependent variables were run. Only variables with statistically significant correlations were used in the linear regression model. The same process was followed for question three with the dependent variable post STEM instructional design mean scores

and the independent variables gender, age, years of teaching experience, nationality, and perceived usefulness and ease of use. Table 6 displays the research models for analyzing STEM instructional design.

Limitations

All surveys were all self-reported. Self-reported data has well known disadvantages and advantages (Gonyea, 2005). In spite of the limitations of self-reported data, this was the most efficient method to measure participants' perceptions of their own self-efficacy and their perceived ease of use and usefulness of the STEM Education Framework. Survey results may not be without some bias as respondents may have completed the survey because they thought it was the expectation. It is possible that participants did not give much thought or insight into the questions being asked.

Several inherent threats to internal validity exist with causal comparative methodology (Brewer & Kuhn, 2010). Internal threats to validity include history, selection, mortality, testing and instrumentation. The SEC intervention took place over a continuous ten-week period. This lengthy time period introduced the threat that participants could quit completing assignments and submitting data (mortality), and it also introduced the threat that participants might be impacted by external learning on the subject matter (history). A requirement for participation in the SEC was that participants must possess the technical ability to log into an online platform – meaning that selection criteria would exclude some otherwise potential participants and therefore bias the population. However, SEC was designed to be fully executed online and intended for participants who had the appropriate technical knowledge and ability, thus ensuring SEC has ecological validity. While the construct of STEM instructional design was measured

through pre-/post-test design, neither the pre- nor post-test required participants to answer content questions. Instead, facilitators of SEC used the STEM Education Framework (2016) to evaluate participants' initial instructional units (pre-test) and their revised instructional units upon the completion of SEC (post-test). Therefore, the internal threat due to testing is mitigated because participants gained no knowledge of the STEM Education Framework (2016) or of STEM instructional practices by completing either test. Instrumentation was also mitigated as a threat to internal validity because the survey procedure and the sentence stems for the survey items remained the same across all points of data collection.

Threats to external validity may occur due to the fact that participants voluntarily enrolled in and completed SEC requirements via online protocols. The online selection process resulted in participants who were more likely to be sensitive to the experience of an online course, resulting in the external threat of interaction of selection and treatment. Furthermore, participants completed SEC online meaning that the threat of interaction of setting and treatment has implications on whether this study could be replicated in an in-person setting. However, SEC was intended for online delivery, thus these threats were necessary to achieve ecological validity.

Delimitations

Delimitations are factors that may influence a study, but are controlled by the researcher (Simon, 2011) and help narrow the scope of a study (Creswell, 2017). The findings were limited to an initial acceptance of 100 participants. Furthermore, participants were required to be K-12 classroom teachers of science, technology,

engineering, or mathematics content areas who were able to effectively communicate in English and access SEC through a specific internet-based learning management system.

Summary

Chapter 3 presented the methodology and procedures used. A quantitative, causal comparative methodology was used, and information regarding the sample population and sample size was discussed. Each of the measures: Demographics, Self-Efficacy, Perceived Usefulness and Ease of Use, and STEM instructional design were discussed in detail along with research question-aligned data analysis procedures. Data analysis involve one-way ANCOVA and linear regression models. Due to the nature of data collected and the means by which the SEC was administered, internal and external threats exist and were described.

CHAPTER 4

FINDINGS

Careers in STEM are becoming increasingly prominent (Bughin et al., 2019) yet many graduates entering the workforce lack essential skills necessary for success in modern careers (Kramer et al., 2014). While educational standards for STEM exist, no metric for inclusion of 21st Century skills has been widely adopted. The New York Academy of Sciences developed and delivered SEC, an online course designed to support the inclusion of essential skills into STEM curricula.

Research Questions

In order to describe and evaluate the effectiveness of SEC, three research questions were defined:

1. Is there a statistically significant difference in SEC participants' post STEM instructional design mean scores and participants' demographics (age, gender, years of teaching experience, and nationality), controlling for pre STEM instructional design mean scores?
2. Is there a relationship between SEC participants' demographics and self-efficacy mean scores on post STEM instructional design mean scores?
3. Is there a relationship between SEC participants' demographics and perceived usefulness and ease of use mean scores on post STEM instructional design mean scores?

Statistical analysis of the quantitative results addresses each of the null hypotheses:

H_0 1: Participants' demographics will have no influence on instructional improvement controlling for initial instructional mean scores.

H₀ 2: Participants' demographics will have no influence on the relationship between self

efficacy and post STEM instructional design mean scores, controlling for initial instructional means scores.

H₀ 3: Participants' demographics will have no influence on the relationship between perceived usefulness and ease of use and post STEM instructional design mean scores,

controlling for initial instructional evidence.

Data Description

Data were obtained from a sample of 45 participants of SEC. Each participant submitted an initial STEM instructional unit as well as a final STEM instructional unit. These units were evaluated by a trained instructor and their scores were used to measure STEM instructional design. Self-efficacy for each essential skill was measured via a unique 100-point scale. Perceived usefulness and ease of use was measured via seven-point Likert Scales. All data collected were checked for errors and imported into Statistical Product and Service Solutions (SPSS) for descriptive and inferential statistical analysis.

Results

The following section presents the results for each research question.

STEM Instructional Design

Research question one was analyzed using four one-way ANCOVAs conducted to determine if there was statistically significant difference between each of the four independent variables (age, gender, years of teaching experience, and nationality) and post STEM instructional design, when controlling for pre STEM instructional design. In order to increase the sample size for grouping variables, age and years of teaching experience were recoded into two groups prior to running the ANCOVAs. Of the participants, 25 (55.6%) were aged 21 – 40 while 20 (44.4%) were aged 41 – 60. Furthermore, 20 participants (44.4%) were in their first ten years of teaching, while 25 (55.6%) were in years 11 – 21+. Table 8 shows the mean and standard deviation of post STEM instructional design scores for each of the groups.

In order to determine if SEC had a significantly different effect on post STEM instructional design based on demographics, four research models corresponding to research question one were created, as illustrated in Table 7. The first model, 1A, compared post STEM instructional design scores of SEC participants aged 21 – 40 with SEC participants aged 41 – 60. The second model, 1B, compared post STEM instructional design scores of males in SEC with females in SEC. The third model, 1C, compared post STEM instructional design scores of SEC participants with 1 – 10 years of teaching experience with SEC participants with 11 – 21+ years of teaching experience. The fourth model, 1D, compared post STEM instructional design scores of US participants of SEC with non-US participants of SEC.

Table 7

ANCOVA Research Models for Analyzing Improvement of STEM Instructional Design Based on Demographics

Model	Research Question	Independent Variable	Dependent Variable	Covariate	Comparison Groups
1A	Is there a statistically significant difference in SEC participants' post STEM instructional design mean scores and participants' demographics (age, gender, years of teaching experience, and nationality), controlling for pre STEM instructional design mean scores?	Age	Post STEM Instructional Design	Pre STEM Instructional Design	Participants Aged 21 – 40 Compared to Participants Aged 41 – 60
1B	Is there a statistically significant difference in SEC participants' post STEM instructional design mean scores and participants' demographics (age, gender, years of teaching experience, and nationality), controlling for pre STEM instructional design mean scores?	Gender	Post STEM Instructional Design	Pre STEM Instructional Design	Males Compared to Females
1C	Is there a statistically significant difference in SEC participants' post STEM instructional design mean scores and participants' demographics (age, gender, years of teaching experience, and nationality), controlling for pre STEM instructional design mean scores?	Years of Teaching Experience	Post STEM Instructional Design	Pre STEM Instructional Design	Participants with 1 – 10 Years of Teaching Experience Compared with 11 – 21+ Years of Teaching Experience
1D	Is there a statistically significant difference in SEC participants' post STEM instructional design mean scores and participants' demographics (age, gender, years of teaching experience, and nationality), controlling for pre STEM instructional design mean scores?	Nationality	Post STEM Instructional Design	Pre STEM Instructional Design	US Participants Compared to Non-US Participants

Table 8*Pre and Post STEM Instructional Design Scores by Grouping Variables*

Independent Variable	Group	Pre STEM Instructional Design Scores		Post STEM Instructional Design Scores	
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Age	21 – 40 (<i>n</i> = 25)	2.12	0.46	2.89	0.51
	41 – 60 (<i>n</i> = 20)	2.17	0.69	3.02	0.48
Gender	Male (<i>n</i> = 16)	2.06	0.67	2.84	0.45
	Female (<i>n</i> = 29)	2.19	0.51	3.01	0.52
Years of Teaching Experience		2.03	0.38		
	1 – 10 (<i>n</i> = 20)			2.84	0.42
	11 – 21+ (<i>n</i> = 25)	2.24	0.68	3.05	0.54
Nationality	US (<i>n</i> = 21)	1.95	0.48	2.97	0.42
	Non-US (<i>n</i> = 24)	2.31	0.60	2.93	0.57

Note: *M* = mean. *SD* = standard deviation.

For research model 1A (see Table 7), a one-way ANCOVA was conducted to determine if there was a statistically difference between post STEM instructional design scores of SEC participants aged 21 - 40 compared with SEC participants aged 41+. As shown in Table 8, the data indicate mean post STEM instructional design score was 0.13 points higher for participants aged 41+ ($M = 3.02$, $SD = 0.48$) compared to participants aged 21 – 40 ($M = 2.89$, $SD = 0.51$).

Table 9 illustrates the results of the ANCOVA for research model 1A which show that age did not have a significant effect on post STEM instructional design scores when controlling for pre STEM instructional design scores, $F(1, 44) = .73$, $p = .399$.

Table 9

*ANCOVA Results: Comparison of Post STEM Instructional Design Scores
Between Age Groups*

<i>Source</i>	<i>Type III Sum of Squares</i>	<i>df</i>	<i>Mean Square</i>	<i>F</i>
Age	0.08	1	0.08	0.73
Pre STEM Instructional Design	5.89	1	5.89	51.49
Error	4.80	42	0.11	

Note. Pre STEM Instructional Design Scores are the covariate. * $p < .05$

For research model 1B (see Table 7), a one-way ANCOVA was conducted to determine if there was a statistically difference between post STEM instructional design scores of SEC male and female participants of SEC. As shown in Table 8, the data indicate mean post STEM instructional design score was 0.17 points higher for female participants ($M = 3.01$, $SD = 0.52$) compared to male participants ($M = 2.84$, $SD = 0.45$). Table 10 illustrates the results of the ANCOVA for research model 1B which show that gender did not have a significant effect on post STEM instructional design scores when controlling for pre STEM instructional design scores, $F(1, 44) = .77$, $p = .386$.

For research model 1C (see Table 7), a one-way ANCOVA was conducted to determine if there was a statistically difference between post STEM instructional design scores of SEC participants with 1 – 10 years of teaching experience compared with SEC participants with 11+ years of teaching experience. As shown in Table 8, the data indicate mean post STEM instructional design score was 0.13 points higher for participants with 11+ years of teaching experience ($M = 3.05$, $SD = 0.55$) compared to participants with 1 –

10 years of teaching experience ($M = 2.84$, $SD = 0.42$). Table 11 illustrates the results of the ANCOVA for research model 1C which show that years of teaching experience did not have a significant effect on post STEM instructional design scores when controlling for pre STEM instructional design scores, $F(1, 44) = .54$, $p = .468$.

Table 10

ANCOVA Results: Comparison of Post STEM Instructional Design Scores Between Males and Females

<i>Source</i>	<i>Type III Sum of Squares</i>	<i>df</i>	<i>Mean Square</i>	<i>F</i>
Gender	0.09	1	0.09	0.77
Pre STEM Instructional Design	5.74	1	5.74	50.31
Error	4.79	42	0.11	

Note. Pre STEM Instructional Design Scores are the covariate. * $p < .05$

For research model 1D (see Table 7), a one-way ANCOVA was conducted to determine if there was a statistically difference between post STEM instructional design scores of US participants of SEC compared with non-US participants of SEC. As shown in Table 8, the data indicate mean post STEM instructional design score was 0.04 points higher for US participants ($M = 2.97$, $SD = 0.42$) compared to non-US participants ($M = 2.93$, $SD = 0.57$). Table 12 illustrates the results of the ANCOVA for research model 1D which show that nationality had a significant, positive effect on post STEM instructional design scores when controlling for pre STEM instructional design scores, $F(1, 44) = 9.11$, $p = .004$.

Table 11

ANCOVA Results: Comparison of Post STEM Instructional Design Scores Between Years of Teaching Experience Groups

<i>Source</i>	<i>Type III Sum of Squares</i>	<i>df</i>	<i>Mean Square</i>	<i>F</i>
Years of Teaching Experience	0.06	1	0.06	0.54
Pre STEM Instructional Design	5.55	1	5.55	48.31
Error	4.82	42	0.12	

Note. Pre STEM Instructional Design Scores are the covariate. *p<.05

Table 12

ANCOVA Results: Comparison of Post STEM Instructional Design Scores Between Nationality Groups

<i>Source</i>	<i>Type III Sum of Squares</i>	<i>df</i>	<i>Mean Square</i>	<i>F</i>
Nationality	0.87	1	0.87	9.11*
Pre STEM Instructional Design	6.83	1	6.83	71.46*
Error	4.01	42	0.09	

Note. Pre STEM Instructional Design Scores are the covariate. *p<.005

Self-Efficacy

Research question two was analyzed using Pearson correlation coefficient to determine the strength of the relationship between the four independent variables (age, gender, years of teaching experience, and nationality) and participants' self-efficacy of each Essential Skill (critical thinking, problem solving, creativity, communication, collaboration, data literacy, and digital literacy and computer science). Table 13 shows the range, mean, and standard deviation of each self-efficacy scale.

Table 13*Self-Efficacy Descriptives*

Self-Efficacy Scale	Range	<i>M</i>	<i>SD</i>
Critical Thinking	0 – 700	443.62	107.34
Problem Solving	0 – 700	489.08	109.93
Creativity	0 – 500	360.03	85.7
Communication	0 – 700	511.19	102.88
Collaboration	0 – 400	305.56	55.47
Data Literacy	0 – 900	626.96	129.66
Digital Literacy & Computer Science	0 – 500	362.12	102.08

Values for Pearson correlation coefficients are displayed in Table 14. While most of the self-efficacy scales returned significant correlational relationships at 0.01 or 0.05 levels, none of the independent variables were correlated at a 0.05 significance with any of the self-efficacy scales. As noted in Table 6, linear regression models were expected to be conducted; however, no significant relationships between independent variables and self-efficacy scales exist. Therefore, no linear regression models are appropriate to run.

Table 14

Correlations of Age, Years of Teaching Experience, Gender, Nationality, and Self-Efficacy

Variable	1	2	3	4	5	6	7
Age	-.025	-.019	.242	.074	.073	.058	.311
Years of Teaching Experience	.067	.130	.106	-.102	.061	-.141	.158
Gender	.006	-.033	-.003	-.141	-.183	.005	.354
Nationality	.043	.116	-.076	-.165	.122	-.043	.215
Self-Efficacy Predictor Variable							
1 Critical Thinking	—	.691**	.598**	.671**	.606**	.345	.390
2 Problem Solving		—	.608**	.672**	.651**	.507*	.489*
3 Creativity			—	.824**	.758**	.658**	.739**
4 Communication				—	.857**	.607**	.422
5 Collaboration					—	.320	.383
6 Data Literacy						—	.060
7 Digital Literacy & Computer Science							—

Note: ** $p \leq .01$ * $p \leq .05$

Perceived Usefulness and Ease of Use

Research question three was analyzed using Pearson correlation coefficient to determine the strength of the relationship between the four independent variables (age, gender, years of teaching experience, and nationality) and participants' perceived usefulness, perceived ease of use, and combined perceived usefulness and ease of use scales. Table 15 shows the range, mean, and standard deviation of each of the scales.

Values for Pearson correlation coefficients are displayed in Table 16. While the results for perceived usefulness, perceived ease of use, and combined perceived usefulness and ease of use returned significant correlational relationships ($p \leq 0.01$), none

of the independent variables were significantly correlated at a 0.05 level with any of the scales. As noted in Table 6, linear regression models were expected to be conducted; however, no significant relationships between independent variables and the perceived usefulness, perceived ease of use, or combined perceived usefulness and ease of use scales exist. Therefore, no linear regression models are appropriate to run.

Table 15*Perceived Usefulness and Ease of Use Descriptives*

Scale	Range	<i>M</i>	<i>SD</i>
Perceived Usefulness	0 – 21	18.17	2.96
Perceived Ease of Use	0 – 21	17.63	3.05
Perceived Usefulness and Ease of Use (Combined)	0 – 42	35.79	5.46

Table 16*Correlations of Age, Years of Teaching Experience, Gender, Nationality and Perceived Usefulness and Ease of Use*

Variable	1	2	3
Age	-.034	.025	-.005
Years of Teaching Experience	-.142	.267	.072
Gender	-.049	-.149	-.109
Nationality	-.403	-.293	-.382
Predictor Variable			
1 Perceived Usefulness	—	.653**	.906**
2 Perceived Ease of Use		—	.912**
3 Perceived Usefulness and Ease of Use			—

Note: ** $p \leq .01$

Summary

Research question one was analyzed using four one-way ANCOVAs conducted to determine if there was statistically significant difference between each of the four independent variables (age, gender, years of teaching experience, and nationality) and post STEM instructional design, when controlling for pre STEM instructional design. Of these independent variables, only nationality had a significant, positive effect on post STEM instructional design scores when controlling for pre STEM instructional design scores, $F(1, 44) = 9.11, p < .005$. Research question two was analyzed using Pearson correlation coefficient to determine the strength of the relationship between the four independent variables (age, gender, years of teaching experience, and nationality) and participants' self-efficacy of each Essential Skill (critical thinking, problem solving, creativity, communication, collaboration, data literacy, and digital literacy and computer science). While most of the self-efficacy scales returned significant correlational relationships at 0.01 or 0.05 levels, none of the independent variables were correlated at a 0.05 significance with any of the self-efficacy scales. Research question three was analyzed using Pearson correlation coefficient to determine the strength of the relationship between the four independent variables (age, gender, years of teaching experience, and nationality) and participants' perceived usefulness, perceived ease of use, and combined perceived usefulness and ease of use scales. While the results for perceived usefulness, perceived ease of use, and combined perceived usefulness and ease of use returned significant correlational relationships ($p \leq 0.01$), none of the independent variables were significantly correlated at a 0.05 level with any of the scales.

CHAPTER 5

DISCUSSION

STEM careers are becoming increasingly prominent (Bughin et al., 2019) and more people are graduating with STEM degrees. However, many STEM positions are going unfilled because many STEM graduates lack the complementary fundamental skills of critical thinking, problem solving, creativity, communication, and collaboration necessary for successful employment (Kramer et al., 2014). It is generally accepted that the purpose of education is to equip people with the skills and knowledge to be productive citizens. Therefore, teachers need support to be able to equip students with the Essential Skills. Given the nature of demands on educators, online courses present a cost and time effective method of supporting professional development of educators.

There are standards in STEM education such as the Next Generation Science Standards and the Common Core State Standards; however, there are no standards or metric for the inclusion of 21st Century skills into STEM instruction. In 2016, the New York Academy of Sciences developed the STEM Education Framework which is a series of holistic rubrics that detail criteria for effective inclusion of 21st Century skills in STEM education. The New York Academy of Sciences developed an online course, STEM Education in the 21st Century (SEC), to support educators as they learn how to use the STEM Education Framework as a tool to improve students' opportunities to develop 21st Century skills in STEM classrooms.

Research Questions

In order to describe and evaluate the effectiveness of SEC, three research questions were defined:

1. Is there a statistically significant difference in SEC participants' post STEM instructional design mean scores and participants' demographics (age, gender, years of teaching experience, and nationality), controlling for pre STEM instructional design mean scores?
2. Is there a relationship between SEC participants' demographics and self-efficacy mean scores on post STEM instructional design mean scores?
3. Is there a relationship between SEC participants' demographics and perceived usefulness and ease of use mean scores on post STEM instructional design mean scores?

Findings and Interpretations

STEM Instructional Design

The primary aim of SEC was to support K-12 STEM educators as they revised an instructional unit so that it provided students with increased opportunities to develop 21st Century skills. In order to understand if certain groups of STEM educators are better suited for the course, demographics (age, years of teaching experience, gender, nationality) were used as independent variables throughout the study. Table 8 displays the means and standard deviations of all demographic groups' pre and post STEM instructional design scores and shows that all groups improved from pre to post

evaluation. Further data analysis showed no statistical significance between any of the demographic variables with the exception of nationality.

While the goal was to understand which demographics were better suited for SEC, it makes perfect sense that the demographics of age, years of teaching experience, and gender would yield no statistical significance between their respective groups. The STEM Education Framework is not a widely distributed resource for educators. Therefore, it is unlikely that any of the participants have previously encountered the STEM Education Framework. Since none of the participants had previously encountered the STEM Education Framework, there would be no way that any participant could have submitted an initial instructional unit that would have been fully aligned. It is plausible that some participants could have previously learned some instructional practices on a few of the Essential Skills, for example the Four C's (critical thinking, communication, collaboration, and creativity) are widely known as being beneficial to students, but it is unlikely that participants had prior in-depth exposure to all seven.

In order to determine whether participants had previously encountered the STEM Education Framework or similar resource, two survey items could be added to course registration: 1) "Have you ever used the STEM Education Framework or a similar resource to support your inclusion of 21st Century skills into your instruction?" 2) "If your answer to the previous question was 'Yes', please name the resource or provide its URL." Selection responses to the first question would take multiple choice format with the options of "Yes" or "No". The response to the second question would be short answer text. While this method may deepen the understanding of impact for future sessions of the course, it might also be prudent to further explore the current data set. To answer

research question one, all seven pre STEM instructional design scores were recoded as a mean score, as were all seven post STEM instructional design scores. In order to evaluate change in pre/post STEM instructional design scores, these means were compared.

However, we might learn about the impact of SEC by comparing respective pre/post mean scores of each essential skill. This would allow the option to compare the change in mean scores and inform which essential skill(s) participants had the most changes. This could lead to more exploratory research to understand the nature of noteworthy results.

Further rationale for the lack in statistically significant results is the fact that education in the US is guided by state or national standards. Many countries and all US states have required educational standards for each of the STEM fields. This often requires that educators teach a list of pre-determined standards to their students for the purpose of helping students pass a standardized test. Standardized tests measure the content knowledge that students have retained rather than the skills they have developed. Therefore, educators must spend more time teaching to the standards than structuring the teaching and learning process so that it provides students opportunities to develop 21st Century skills. Adding the following additional question to the enrollment form may support understanding of the degree to which teachers are encouraged to provide students' opportunities to develop 21st Century skills: "To what degree do you currently feel supported by your school/district administrators to include 21st Century skills development in your standards-aligned lesson planning?" This item could be measured with a 100-point sliding scale with zero, "Not at all", 50, "A moderate amount", 100, "A great deal."

It also makes sense that nationality had a statistically significant difference between pre and post data. Looking at Table 8, it is evident that nationality is significant due to US participants making the greatest gains from pre to post ($\Delta M = +1.02$). This can be explained based on several aspects of how SEC was developed. SEC was primarily developed by a US author who has exclusively US teaching experience. This is relevant because the tools, strategies, examples, and structure of the course are more common to the experiences of US educators. While the components of the course are relevant to non-US educational settings, it might take more work on the part of the participants to make sense of the course materials. Further, the course was developed and delivered in US English dialect. Therefore, it is more likely that non-US participants required additional cognitive steps to interpret and apply the content of SEC.

While it is fair to say that participants of SEC improved their ability to develop STEM instructional units, as measured by the STEM Education Framework, more research would likely provide additional understanding of how well this course supports participants. First, as previously identified, many participants have likely had some exposure to the Four Cs. It would be worth exploring which of the essential skills participants showed the most and least gains. Areas of little gain could show areas where participants have had previous exposure. Areas of little gain could help identify components of the course that are in need of improvement or are areas where educators need further support to effectively implement. Second, it is plausible that significant results were rarely found because of the low sample size ($n = 45$). Delivering SEC through the same methods to more participants would provide additional data points and enhance data analysis.

Exploring how SEC impacted participants' ability to develop STEM instructional units led to two interesting observations. First, delivering professional development to educators in an online environment can be successful. Throughout SEC, participants learned about and applied a unique essential skill to their own instruction each week of the course. When educators are provided quality support and direction, they are more than capable of, not only learning new content, but applying the new content to their instruction in quick turnaround. Second, based on the fact that all participant groups improved their STEM instructional design from pre to post (see Table 8), it is clear that there are educators who stand to benefit from applying the STEM Education Framework to their instruction.

Self-Efficacy

Research question two seeks to understand the relationships between the independent variables (age, years of teaching experience, gender, and nationality) and SEC participants' perceived self-efficacy for each of the essential skills. It was discovered that self-efficacy of the seven essentials skills are highly related to each other; however, none of the independent variables had any significant relationship with any of the self-efficacy scales. The lack of significant relationships between the independent variables and self-efficacy is logical because an educator's age, years of teaching experience, gender, or nationality would not have an impact on their perceived ability to complete a task or control their environment based on a never before experienced set of criteria. In this case, participants had never before experienced the STEM Education Framework. Therefore, it is logical that no grouping variable (see Table 8) had a stronger relationship with any of the self-efficacy scales than another. To support this claim, it

would be helpful to have data from more participants. Only 45 people participated in SEC and many of them did not complete all weekly surveys. Increasing the number of participants who complete the surveys would enable a more accurate analysis of this data.

It would also be helpful to understand how participants' self-efficacy changed throughout the course. Therefore, a recommendation would be to pose the self-efficacy questions to participants prior to the launch of SEC and at the end of each module.

While no statistically significant results regarding the independent variables and participants' self-efficacy of executing the STEM Education Framework were discovered, most of the self-efficacy sub scales were highly correlated to each other (see Table 14). Including these questions on future studies that analyze the application of the STEM Education Framework to teacher PD would be fruitful in understanding the degree to which participants have confidence in their ability to include specific criteria of the STEM Education Framework.

Perceived Usefulness and Ease of Use

Research question three seeks to understand the relationships between the independent variables (age, years of teaching experience, gender, and nationality) and SEC participants' perceived usefulness and ease of use of the STEM Education Framework. It was found that perceived usefulness and perceived ease of use were highly related to each other and to their combined score. However, none of the independent variables had any significant relationship with perceived usefulness, perceived ease of use, or their combined score. The lack of significant relationships between the independent variables and perceived usefulness and ease of use is logical because an educator's age, years of teaching experience, gender, or nationality would not have a

logical impact on their perception of the STEM Education Framework's usefulness or how easy it is to use. Therefore, it is logical that no grouping variable (see Table 8) had a stronger relationship with perceived usefulness and ease of use.

While the data indicate that participants have sufficient perceived usefulness and ease of use, the data do not indicate whether there is, as Radner and Rothschild (1975) describe, an ease of use → usefulness → usage chain of causality. In order to determine if participants continue to use the STEM Education Framework, follow-up surveys should be administered.

Based on the data that indicate participants' improvement in developing instruction that is aligned to the STEM Education Framework (see Table 8) and participants' perceived usefulness and ease of use scores, it can be concluded that the STEM Education Framework is worthwhile tool to provide teachers to enhance their inclusion of 21st Century skills within their STEM instructional design.

Conclusion

Based on the data that indicate SEC participation improved the development of instruction that aligns with the STEM Education Framework (see Table 8), it can be concluded that SEC is a worthwhile online PD program that provides the pedagogical skills teachers need to enhance their inclusion of 21st Century skills within their STEM instructional design. Given perceived usefulness and ease of use scores by the participants (see Table 15) it can be concluded that participants will likely continue to use the STEM Education Framework in their professional future. Also noteworthy is that over 46-percent of participants completed SEC, compared to 6.5-percent in similar free courses (Jordan, 2014). This indicates that participants found value in persisting

throughout the course. Lastly, because SEC had a high number of international participants who completed the course, it would seem logical that the STEM Education Framework and SEC should be considered as viable options for advancing 21st Century skills in STEM education both in the US and internationally.

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APPENDIX A

STEM EDUCATION FRAMEWORK CONTENTS



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STEM EDUCATION FRAMEWORK
INTRODUCTION

Introduction

The Global STEM Alliance (GSA) STEM Education Framework aims to identify best practices in science, technology, engineering, and mathematics (STEM) education. It reflects current education research and draws on innovative and effective practices employed around the world.

The framework details 26 features of quality STEM education in 3 essential areas:

- **Core Competencies:** To what extent are students provided with opportunities to develop 21st-century skills needed to thrive in the modern workplace?
- **Instructional Design:** To what extent do the materials and/or program design reflect research-based pedagogy and a cohesive system of learning objectives, supports, and assessment resources?
- **Implementation:** To what extent are necessary supports or services available to facilitate distribution and ensure effective implementation?

This framework is intended to be used by anyone engaged in STEM education—curriculum developers, content providers, teachers, students, parents, school leaders, policymakers, and philanthropists—to help guide the development and evaluation of high-quality instructional programs and materials. It was developed by the New York Academy of Sciences in collaboration with SRI International and an advisory board of STEM education experts. For details about the development process and research supporting the framework, see *STEM Education Framework Research Foundations*.

STEM EDUCATION FRAMEWORK**PART A: CORE COMPETENCIES**

Part A: Core Competencies

Part A has two sections: *Essential Skills* are competencies that, in addition to content knowledge, students must develop to thrive in the modern workplace; *Supporting Attributes* are competencies that facilitate the development of and enhance these essential skills. To be Exemplary in these areas, materials must include explicit guidance for instruction and assessment of a given competency, including rubrics or instructions for interpreting assessment outcomes.

A.1 Essential Skills

A.1.1 Critical Thinking

Exemplary	Developing	Basic	Undeveloped
<p>Students have opportunities to evaluate multiple sources of information, evidence, and primary material; select appropriate material to support arguments; critique the work of others; and differentiate evidence from inference and opinion.</p> <p>Activities include the use of scientific procedures to test students' hypotheses.</p> <p>Students are supported and have opportunities to apply one or more perspectives to reason about problems, experimental procedures, and phenomena (e.g., computational, systems, or design thinking) when developing arguments, critiques, or hypotheses.</p> <p>Supports are provided to facilitate teacher and student discussion and reasoning when evaluating sources and critiquing each other's work.</p>	<p>Students have opportunities to evaluate sources of information, evidence, and primary materials; critique the work of others; and use evidence to build an argument, but not as integral components of instructional activities.</p> <p>Students have opportunities to make predictions based on given information (if X, then Y) and form conclusions or generalizations about phenomena.</p> <p>Students are supported and have opportunities to apply one or more perspectives to reason about problems and phenomena (e.g., computational, systems, or design thinking).</p>	<p>Students have limited opportunities to review primary materials or sources that allow them to evaluate and integrate new knowledge.</p> <p>Students have opportunities to make predictions based on given information (if X, then Y), but are not asked to generalize or test hypotheses.</p>	<p>Students do not have opportunities to evaluate information or evidence presented; information is imparted from a unitary perspective.</p> <p>Materials do not include or reference outside resources.</p> <p>Students are not asked to make predictions, test hypotheses, or build arguments.</p>

Is this a stated learning outcome? ☐ Yes ☐ No

Rating: E / D / B / U

STEM EDUCATION FRAMEWORK
PART A: CORE COMPETENCIES



A.1.2 Problem Solving

Exemplary	Developing	Basic	Undeveloped
<p>Students have opportunities to develop their ability to generate solutions to a range of STEM-based problems and scenarios, including organizing ideas, defining goals and milestones, and executing plans.</p> <p>Materials support the use and evaluation of a range of approaches to problem solving, including the scientific method and design thinking.</p> <p>Students are supported and have opportunities to apply one or more solutions to a range of STEM-based problems and scenarios.</p> <p>Supports are provided to facilitate teacher and student reasoning about challenges that occur during problem solving, with an emphasis on strategy, creativity, collaboration, and persistence.</p>	<p>Students have opportunities to develop their ability to generate solutions to a range of STEM-based problems and scenarios, including organizing ideas, defining goals and milestones, and executing plans.</p> <p>Materials support the use and evaluation of a range of approaches to problem solving, including the scientific method and design thinking.</p>	<p>Students have opportunities to develop their ability to generate a single solution to a range of STEM-based problems and scenarios, including organizing ideas, defining goals and milestones, and executing plans.</p>	<p>Students are led through activities step by step.</p> <p>Teachers may model problem-solving skills, but students do not engage with these skills, and therefore do not have opportunities to develop them.</p>

Is this a stated learning outcome? ____ Yes ____ No

Rating: E / D / B / U

Notes:

STEM EDUCATION FRAMEWORK**PART A: CORE COMPETENCIES****A.1.3 Creativity**

Exemplary	Developing	Basic	Undeveloped
<p>Students have multiple opportunities to approach problems from many different perspectives, including their own. Novel approaches or solutions are explicitly valued.</p> <p>Activities promote exploration of varied approaches to a task, allowing students to devise their own path. Teacher and/or student supports are included to facilitate synthesis of activity outcomes and reflection upon the value of novel and innovative approaches and solutions.</p> <p>Materials encourage students to develop work products (e.g., explanations, representations, presentations) that express their perspectives or approaches to activities.</p>	<p>Students have opportunities to approach problems from different perspectives and are encouraged to generate and adopt novel, innovative approaches.</p> <p>Teacher and/or student supports are included to facilitate synthesis of activity outcomes and reflection on the value of novel and innovative approaches and solutions.</p> <p>Materials encourage students to develop work products (e.g., explanations, representations, presentations) that express their perspectives or approaches to activities.</p>	<p>Activities do not explicitly present opportunities for students to approach problems from different perspectives; however, materials encourage students to develop work products (e.g., explanations, representations, presentations) that express their perspectives or approaches.</p>	<p>Students do not have opportunities to approach problems from different perspectives.</p>

Is this a stated learning outcome? ☐ Yes ☐ No

Rating: E / D / B / U

Notes:

STEM EDUCATION FRAMEWORK**PART A: CORE COMPETENCIES****A.1.4 Communication**

Exemplary	Developing	Basic	Undeveloped
<p>Students have frequent and varied opportunities to practice and demonstrate their ability to communicate clearly, accurately, and/or persuasively about STEM topics to multiple audiences, both formal and informal.</p> <p>Students frequently use multi-modal methods, such as drawings, images, visual representations, and models, to convey ideas.</p> <p>Communication is integral to instructional activities and goals.</p> <p>Supports are provided to facilitate teacher and student discussion and reasoning about forms and purposes of communication in STEM, as well as evaluation of their own and others' communication skills.</p>	<p>Students have periodic opportunities to practice and demonstrate their ability to communicate clearly, accurately, and/or persuasively about STEM topics.</p> <p>Activities do not require students to address multiple audiences or use multi-modal methods to convey ideas.</p> <p>Communication is a component of some instructional activities.</p>	<p>Students have occasional opportunities to practice and demonstrate their ability to communicate clearly, accurately, and/or persuasively about STEM topics.</p> <p>Activities do not require students to address multiple audiences or use multi-modal methods to convey ideas.</p> <p>Communication is a component of select instructional activities (e.g., capstone activities only).</p>	<p>Students do not have opportunities to practice or demonstrate their ability to communicate clearly, accurately, and/or persuasively about STEM topics.</p>

Is this a stated learning outcome? ☐ Yes ☐ No

Rating: E / D / B / U

Notes:

STEM EDUCATION FRAMEWORK
PART A: CORE COMPETENCIES



A.1.5 Collaboration

Exemplary	Developing	Basic	Undeveloped
<p>Students have frequent opportunities to engage in group work. Teacher and/or student supports are included to help students work together to plan, organize, and execute activities.</p> <p>Activities are structured to support co-construction of knowledge and work products (e.g., students are assigned roles within groups so that each student can contribute).</p>	<p>Students have periodic opportunities to engage in group work. Teacher and/or student supports are included to help students work together to plan, organize, and execute activities.</p> <p>Activities do not explicitly support co-construction of knowledge or work products (e.g., roles are not defined for students; most subtasks can be completed independently).</p>	<p>Students have occasional opportunities to engage in group work; however, supports to help students work together to plan, organize, and execute activities are not provided.</p> <p>Activities do not explicitly support co-construction of knowledge or work products (e.g., roles are not defined for students; most subtasks can be completed independently).</p>	<p>Students do not have opportunities to engage in group work.</p>

Is this a stated learning outcome? ____ Yes ____ No

Rating: E / D / B / U

Notes:

STEM EDUCATION FRAMEWORK**PART A: CORE COMPETENCIES****A.1.6 Data Literacy**

Exemplary	Developing	Basic	Undeveloped
<p>Activities require students to engage with qualitative and quantitative data as part of analytical tasks such as problem solving, investigation, and design.</p> <p>Materials provide teacher and student guidance for data-related activities, including technical support for use of necessary tools or technology.</p> <p>Materials support student reasoning about data generation, analysis, representation, and interpretation, as well as appropriate and ethical uses of data and data methods in various contexts.</p>	<p>Activities require students to engage with qualitative and quantitative data as part of analytical tasks such as problem solving, investigation, and design.</p> <p>Materials provide teacher and student guidance for data-related activities, including technical support for use of necessary tools or technology.</p>	<p>Activities provide opportunities for students to engage with qualitative and/or quantitative data.</p>	<p>Activities do not provide opportunities for students to engage with qualitative or quantitative data.</p>

Is this a stated learning outcome? ☐ Yes ☐ No

Rating: E / D / B / U

Notes:

STEM EDUCATION FRAMEWORK**PART A: CORE COMPETENCIES****A.1.7 Digital Literacy & Computer Science**

Exemplary	Developing	Basic	Undeveloped
<p>Computer science concepts are integrated into STEM content when appropriate (e.g., as part of problem solving, critical thinking, and logic-based reasoning).</p> <p>When technology tools are used, appropriate teacher and student supports are provided to equip students with the digital literacy skills needed to use the tools.</p>	<p>Computer science concepts are presented, but are not integrated into STEM content.</p> <p>When technology tools are used, appropriate teacher and student supports are provided to equip students with the digital literacy skills needed to use the tools.</p>	<p>When technology tools are used, appropriate teacher and student supports are provided to equip students with the digital literacy skills needed to use the tools.</p>	<p>Digital literacy and computer science concepts are not introduced.</p>

Is this a stated learning outcome? ____ Yes ____ No

Rating: E / D / B / U

Notes:

APPENDIX B



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STEM Education in the 21st Century

Online Course Syllabus

October 6 - December 14, 2019

[Course Description](#)

[Learning Outcomes](#)

[Course Authors](#)

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[Class Schedule](#)

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Course Description

This 10-week online course supports K-12 teachers of science, technology, engineering, and mathematics (STEM) through the process of *refining an instructional unit* for K-12 students so that the resulting unit is aligned to the [New York Academy of Sciences' STEM Education Framework](#). Participants will explore the research behind the framework and apply it to create a unit of study designed to foster 21st-century skills in the context of STEM. **Enrollment is restricted to current STEM educators.**

Throughout this course, participants will **revise** (not create from scratch) a unit of instruction that fits into the contexts of their classrooms. The goal is for participants to revise a unit of instruction that they can apply in their classrooms immediately after the course is complete.

- **Participants will submit this instructional unit (including all lesson plans, student handouts, videos, slide decks, assessments, etc.) when they apply for entry to the course.**
- Participants should have intimate knowledge of the instructional unit before the course begins. It is highly recommended that participants have previously used this unit of instruction in their own classrooms.
- This instructional unit should be the participant's original work and/or one that can be edited and revised by the participant.
- This unit can fall under any STEM category for any grade level.

Learning Outcomes

In this course, participants will:

- Explore the benefits of equipping students with STEM skills and attributes, including essential 21st-century skills
- Demonstrate understanding of best practices in K-12 STEM instruction
- Evaluate various STEM pedagogical methods
- Revise an instructional unit that can be used in K-12 STEM classrooms



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Course Authors

- Chris Link, [New York Academy of Sciences](#)
- Hank Nourse, [New York Academy of Sciences](#)
- Britte Haugan Cheng, PhD, [MenloEDU](#)

Facilitators

The course is facilitated by an experienced educator under supervision of at least one of the course authors. Participants will have access to their instructors through the online course portal. Instructors will respond to participant requests in a timely manner.

Class Schedule

This is a 10-week online course with an additional two weeks for instructor evaluation of final projects. It is an asynchronous course and does not have specific meeting times; however, participants will have scheduled due dates each week. Participants are expected to complete progress toward their final project and provide feedback to peers on a weekly basis. Continue reading for additional information.

Weekly Schedule

Participants will complete the following each week:

Day(s) of the Week	Expectations of Participants
Sunday - Saturday	<ol style="list-style-type: none"> 1. Watch video content 2. Reflect on and consider new instructional practices 3. Complete assignments that will be uploaded to your community/study group forum
Saturday (by 11:59pm Eastern time)	<ol style="list-style-type: none"> 1. Respond to the weekly discussion by posting in the online discussion forum.

Format

- This is a ten-week online course with an additional two weeks for instructors to evaluate final projects.
- Weekly activities for participants include:
 - Watching pre-recorded video lectures
 - Developing aspects of an instructional unit that, by the end of the course, can be implemented in the participant's classroom
 - Providing feedback on peers' assignments via the discussion board
 - Peer feedback is intended to encourage reflection, community, and collaboration on the teaching and learning processes in participants' classrooms.
- Final Project: Throughout the course, participants will build elements of an instructional unit that applies research-based instruction and assessment practices. The final project will be an assembly and final submission of the weekly assignments as a cohesive instructional unit.



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Support Services

- Technical support is available by calling 212.298.8600 or emailing educatortraining@nyas.org.
- The New York Academy of Sciences welcomes learners with disabilities into the course and will make reasonable accommodations for them. Please contact educatortraining@nyas.org if you require information about accommodation services. These services are available only to registered students with documented disabilities. Please submit requests at least two weeks prior to the start of the course.

Grading

Final grades for this course will be either "Pass" or "Fail". Questions about course grades should be addressed to the instructor. See below for more details.

Evaluations of participant-submitted final projects are based on the [STEM Education Framework](#). Participants will use the framework as a tool to develop/revise learning activities, assessments, etc. that will ultimately comprise a coherent final project.

Final Grade Calculation

Participants' final grades will be calculated as follows:

Grade Category	% of Final Grade
Online Participation & Peer Feedback	60
Final Project	40

Grading Policies

- Anything submitted for this course must be original work or borrowed with permission. References to any resource materials are expected, and proper citation is required.
- Anything submitted after its due date will receive an automatic 10% reduction in possible grade.
- Submissions 7 days after its due date will not be accepted and will receive a grade of zero.
- Revised assignments that incorporate instructor feedback will be accepted until the course ends.

Explanation of Assignments

- Online Participation & Peer Feedback: This will be evaluated based on the quality and consistency of contributions to the discussion forum. Participants are expected to provide weekly feedback on concerns and reflections submitted by peers in the course.
 - An evaluation rubric will be made available for participants so they know how they will be assessed.
- Final Project: The Final project consists of three assignments that take place a two times throughout the course. The STEM Education Framework will serve as the rubric for the final project.
 - The first assignment is a Self-Evaluation that takes place in the 1st week of the course.
 - The second assignment is also known as a "Growth Portfolio". Participants will update their growth portfolio as needed throughout the course.
 - The third and final assignment is a resubmission of the instructional unit that participants enhanced throughout the course. This assignment is the assembly of all components (ie. worksheets, handouts,



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lesson plans, etc.) of the updated/revised instructional unit that participants developed throughout the course.

Weekly Overviews & Expectations

Week 1: What is the STEM Education Framework and how does my instruction align?

The course begins with an introduction to the STEM Education Framework: the reasons for the development of the Framework, the research that informed its development, and the practical applications of the Framework. We will set the stage for the remainder of the course by completing a self-assessment: an authentic evaluation of how our instruction addresses the Essential Skills: competencies that, in addition to STEM content knowledge, students must develop to thrive in the modern workplace

Expectations of Participants

- Examine the STEM Education Framework as a tool for designing instruction by watching the lecture.
- Understand the relationship between the performance levels of the Framework.
- Complete the assignment and post it to the community forum by the due date.
- Provide feedback to peers via the community forum.

Weeks 2 - 8: Exploring the Essential Skills

Each week we will explore a new Essential Skill that is identified in the STEM Education Framework. See the table below for the order of Essential Skills. Participants will reflect on their unit of instruction and consider ways to improve its alignment to the abcd so that it gives students increased opportunity to develop the Essential Skills.

Note that participants are required to include at least five out of the seven Essential Skills in their final projects.

Participant Expectations

- Examine the research behind the Essential Skill for each week by watching the expert lecture.
- Consider strategies and develop instructional materials so that your unit improves in at least five out of the seven Essential Skills.
 - Revise the unit you submitted at the beginning of the course to improve in proficiency for at least five out of the seven Essential Skills.
 - Continuously update your Growth Portfolio .
- Collaborate with peers and respond to the weekly discussion prompt via the community forum each week.

Weeks 9: Work on final project

Creating high-quality instructional units takes time. During weeks 7-9, participants will revise the unit they submitted with their application to reflect the Core Competencies and Instructional Design Principles they studied throughout the course.

Participant Expectations

- Revise the unit you submitted at the beginning of the course to improve in proficiency for at least five out of the seven Essential Skills.
- Collaborate with peers via the community forum each week.



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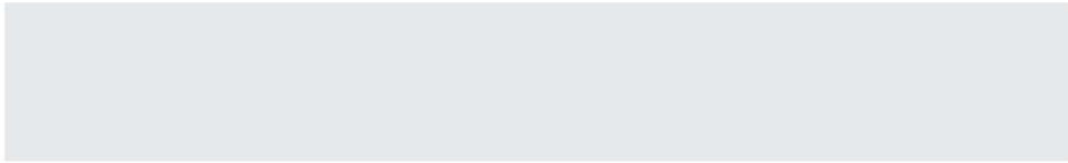
Week 10: Final Projects DueExpectations of Participants

- Final projects must be submitted by 11:59pm Eastern on the due date indicated in the "Assignment Due Dates" section below.

Assignment Due Dates**** All assignments are due by 11:59pm Eastern on the date indicated below ****

Week #	Topic	Assignment	Due Date
1	Exploring the STEM Education Framework	Post to the Discussion Board	Wed, Oct 9, 2019
		Post Self-Assessment	Sat, Oct 12, 2019
		Upload Instructional Unit as Portfolio	Sat, Oct 12, 2019
2	Critical Thinking	Post to the Discussion Board	Sat, Oct 19, 2019
3	Problem Solving	Post to the Discussion Board	Sat, Oct 26, 2019
4	Creativity	Post to the Discussion Board	Sat, Nov 2, 2019
5	Communication	Post to the Discussion Board	Sat, Nov 9, 2019
	Mid-Way Evaluation	Post Current Status of Growth Portfolio	Sat, Nov 9, 2019
6	Collaboration	Post to the Discussion Board	Sat, Nov 16, 2019
7	Data Literacy	Post to the Discussion Board	Sat, Nov 23, 2019
8	Digital Literacy & Computer Science	Post to the Discussion Board	Sat, Nov 30, 2019
9	Work on Final Projects	Post to the Discussion Board	Sat, Dec 7, 2019
10	Submit Final Project	Post Revised Instructional Unit	Sat, Dec 14, 2019
Note: Participants will receive their final grades of "Pass" or "Fail" on or by			Sat, Dec 28, 2019

APPENDIX C

**Critical Thinking: Week 2 Survey**

* 1. The video this week was helpful to me.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

* 2. I am satisfied with the amount of time it took me to complete course requirements this week.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

* 3. I am satisfied with my interactions with my course facilitator.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree
- ☐ Not Applicable

* 4. The Diigo Library of resources was helpful to me this week.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree
- ☐ Not Applicable

* 5. To what extent do you agree with the following statements with regards to participation this week's **module**: Participation in this week's **module** has:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
deepened my understanding of how to give my students opportunities to develop Critical Thinking Skills.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
led to a change in how I plan units/lessons.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
improved my ability to include instructional strategies that promote Critical Thinking in students.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- * 6. To what extent do you agree with the following statements with regards to participation this week's **discussion**: Participation in this week's **discussion** has:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
deepened my understanding of how to give my students opportunities to develop Critical Thinking Skills.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
led to a change in how I plan units/lessons.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
improved my ability to include instructional strategies that promote Critical Thinking in students.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- * 7. To what degree can you include instructional strategies that enhance your students' opportunities to develop Critical Thinking skills?

None ☐ Some ☐ A Great Deal ☐

- * 8. To what degree can you give students opportunities to evaluate multiple sources of information, evidence, and/or primary material?

None ☐ Some ☐ A Great Deal ☐

- * 9. To what degree can you give students opportunities to select appropriate material to support arguments?

None ☐ Some ☐ A Great Deal ☐

- * 10. To what degree can you give students opportunities to critique the work of others?

None ☐ Some ☐ A Great Deal ☐

- * 11. To what degree can you give students opportunities to differentiate evidence from inference and opinion?

None Some A Great Deal



- * 12. To what degree can you include instructional activities that use scientific procedures to test students' hypotheses?

None Some A Great Deal



- * 13. To what degree can you give students discussion and reasoning supports when they evaluate sources and critique each other's work?

None Some A Great Deal

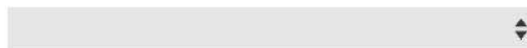


- * 14. To what degree do you feel that you will likely continue to incorporate Critical Thinking skills in your instruction after this course is over?

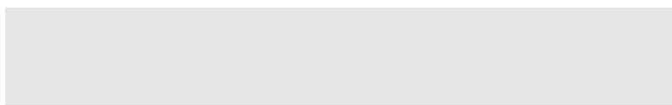
None Some A Great Deal



- * 15. About how much time did you spend completing course requirements this week?



16. Do you have any recommendations on how to improve any aspect of your experience this week? Would you like to share feedback that was not directly asked in the questions above? Would you like to provide additional detail to any of your responses above?





Problem Solving: Week 3 Survey

* 1. The video this week was helpful to me.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

* 2. I am satisfied with the amount of time it took me to complete course requirements this week.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

* 3. I am satisfied with my interactions with my course facilitator.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree
- ☐ Not Applicable

* 4. The Diigo Library of resources was helpful to me this week.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree
- ☐ Not Applicable

* 5. To what extent do you agree with the following statements with regards to participation this week's **module**: Participation in this week's **module** has:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
deepened my understanding of how to give my students opportunities to develop Problem Solving Skills.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
led to a change in how I plan units/lessons.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
improved my ability to include instructional strategies that promote Problem Solving in students.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- * 6. To what extent do you agree with the following statements with regards to participation this week's **discussion**: Participation in this week's **discussion** has:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
deepened my understanding of how to give my students opportunities to develop Problem Solving Skills.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
led to a change in how I plan units/lessons.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
improved my ability to include instructional strategies that promote Problem Solving in students.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- * 7. To what degree can you include instructional strategies that enhance your students' opportunities to develop Problem Solving skills?

None	Some	A Great Deal
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- * 8. To what degree can you give students opportunities to develop their abilities to generate solutions to a range of STEM-based problems and scenarios?

None	Some	A Great Deal
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- * 9. To what degree can you give students opportunities to organize their ideas?

None	Some	A Great Deal
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- * 10. To what degree can you give students opportunities to define goals and milestones?

None	Some	A Great Deal
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* 11. To what degree can you give students opportunities to execute plans?

None Some A Great Deal

A horizontal slider bar with a circular handle at the far left end, corresponding to the 'None' label. The bar is light gray, and the labels 'None', 'Some', and 'A Great Deal' are positioned above it.

* 12. To what degree can you use materials that support the use and evaluation of a range of approaches to problem solving, including the scientific method and design thinking?

None Some A Great Deal

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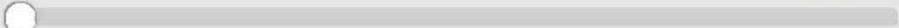
* 13. To what degree can you support students with opportunities to apply one or more solutions to a range of STEM-based problems and scenarios?

None Some A Great Deal

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* 14. To what degree do you feel that you will likely continue to incorporate Problem Solving skills in your instruction after this course is over?

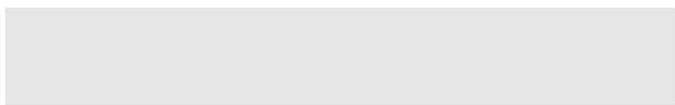
None Some A Great Deal

A horizontal slider bar with a circular handle at the far left end, corresponding to the 'None' label. The bar is light gray, and the labels 'None', 'Some', and 'A Great Deal' are positioned above it.

* 15. About how much time did you spend completing course requirements this week?

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16. Do you have any recommendations on how to improve any aspect of your experience this week? Would you like to share feedback that was not directly asked in the questions above? Would you like to provide additional detail to any of your responses above?

A light gray rectangular text input area.



Creativity: Week 4 Survey

* 1. The video this week was helpful to me.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

* 2. I am satisfied with the amount of time it took me to complete course requirements this week.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

* 3. I am satisfied with my interactions with my course facilitator.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree
- ☐ Not Applicable

* 4. The Diigo Library of resources was helpful to me this week.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree
- ☐ Not Applicable

* 5. To what extent do you agree with the following statements with regards to participation this week's **module**: Participation in this week's **module** has:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
deepened my understanding of how to give my students opportunities to develop Creativity Skills.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
led to a change in how I plan units/lessons.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
improved my ability to include instructional strategies that promote Creativity in students.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- * 6. To what extent do you agree with the following statements with regards to participation this week's **discussion**: Participation in this week's **discussion** has:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
deepened my understanding of how to give my students opportunities to develop Creativity Skills.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
led to a change in how I plan units/lessons.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
improved my ability to include instructional strategies that promote Creativity in students.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- * 7. To what degree can you include instructional strategies that enhance your students' opportunities to develop Creativity skills?

None	Some	A Great Deal
<input type="radio"/>		

- * 8. To what degree can you give students multiple opportunities to approach problems from many different perspectives, including their own?

None	Some	A Great Deal
<input type="radio"/>		

- * 9. To what degree can you design learning experiences where activities promote exploration of varied approaches to a task, allowing students to devise their own path?

None	Some	A Great Deal
<input type="radio"/>		

- * 10. To what degree can you include supports for students to facilitate their synthesis of activity outcomes and reflection upon the value of novel and innovative approaches and solutions?

None Some A Great Deal



- * 11. To what degree can you include materials that encourage students to develop work products (e.g. explanations, representations, presentations) that express their perspectives or approaches to activities?

None Some A Great Deal



- * 12. To what degree do you feel that you will likely continue to incorporate Creativity skills in your instruction after this course is over?


None Some A Great Deal



- * 13. About how much time did you spend completing course requirements this week?



14. Do you have any recommendations on how to improve any aspect of your experience this week? Would you like to share feedback that was not directly asked in the questions above? Would you like to provide additional detail to any of your responses above?



15. What are you liking most about this course? What is going well? What is your favorite part of the course?





Communication: Week 5 Survey

* 1. The video this week was helpful to me.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

* 2. I am satisfied with the amount of time it took me to complete course requirements this week.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

* 3. I am satisfied with my interactions with my course facilitator.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree
- ☐ Not Applicable

* 4. The Diigo Library of resources was helpful to me this week.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree
- ☐ Not Applicable

* 5. To what extent do you agree with the following statements with regards to participation this week's **module**: Participation in this week's **module** has:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
deepened my understanding of how to give my students opportunities to develop Communication Skills.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
led to a change in how I plan units/lessons.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
improved my ability to include instructional strategies that promote Communication in students.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- * 6. To what extent do you agree with the following statements with regards to participation this week's **discussion**: Participation in this week's **discussion** has:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
deepened my understanding of how to give my students opportunities to develop Communication Skills.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
led to a change in how I plan units/lessons.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
improved my ability to include instructional strategies that promote Communication in students.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- * 7. To what degree can you include instructional strategies that enhance your students' opportunities to develop Communication skills?

None	Some	A Great Deal
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- * 8. To what degree can you give students frequent and varied opportunities to practice and demonstrate their ability to communicate clearly, accurately, and/or persuasively about STEM topics to *formal* audiences?

None	Some	A Great Deal
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- * 9. To what degree can you give students frequent and varied opportunities to practice and demonstrate their ability to communicate clearly, accurately, and/or persuasively about STEM topics to *informal* audiences?

None	Some	A Great Deal
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- * 10. To what degree can you give students frequent opportunities to use multi-modal methods, such as drawings, images, visual representations, and models, to convey ideas?

None Some A Great Deal



- * 11. To what degree is communication integral to your instructional activities and goals?

None Some A Great Deal



- * 12. To what degree can you include supports to facilitate student discussion and reasoning about forms and purposes of communication in STEM?

None Some A Great Deal



- * 13. To what degree can you give students supports to evaluate their own and others' communication skills?

None Some A Great Deal



- * 14. To what degree do you feel that you will likely continue to incorporate Communication skills in your instruction after this course is over?

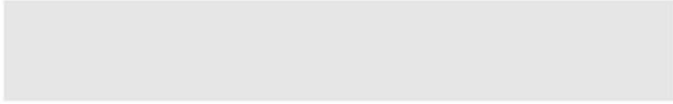
None Some A Great Deal



- * 15. About how much time did you spend completing course requirements this week?



16. Do you have any recommendations on how to improve any aspect of your experience this week? Would you like to share feedback that was not directly asked in the questions above? Would you like to provide additional detail to any of your responses above?



17. What do you like about the Diigo Library of resources that is provided with this course?





Collaboration: Week 6 Survey

* 1. The video this week was helpful to me.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

* 2. I am satisfied with the amount of time it took me to complete course requirements this week.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

* 3. I am satisfied with my interactions with my course facilitator.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree
- ☐ Not Applicable

* 4. The Diigo Library of resources was helpful to me this week.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree
- ☐ Not Applicable

* 5. To what extent do you agree with the following statements with regards to participation this week's **module**: Participation in this week's **module** has:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
deepened my understanding of how to give my students opportunities to develop Collaboration Skills.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
led to a change in how I plan units/lessons.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
improved my ability to include instructional strategies that promote Collaboration in students.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- * 6. To what extent do you agree with the following statements with regards to participation this week's **discussion**: Participation in this week's **discussion** has:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
deepened my understanding of how to give my students opportunities to develop Collaboration Skills.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
led to a change in how I plan units/lessons.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
improved my ability to include instructional strategies that promote Collaboration in students.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- * 7. To what degree can you include instructional strategies that enhance your students' opportunities to develop Collaboration skills?

None	Some	A Great Deal
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- * 8. To what degree can you give students opportunities to engage in group work?

None	Some	A Great Deal
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- * 9. To what degree can you give students supports for working together to plan, organize and execute activities?

None	Some	A Great Deal
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- * 10. To what degree can you give students support to co-construct knowledge and work products?

None	Some	A Great Deal
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* 11. To what degree do you feel that you will likely continue to incorporate collaboration skills in your instruction after this course is over?

None Some A Great Deal

* 12. About how much time did you spend completing course requirements this week?

13. Do you have any recommendations on how to improve any aspect of your experience this week? Would you like to share feedback that was not directly asked in the questions above? Would you like to provide additional detail to any of your responses above?

14. How has your facilitator enhanced your experience in this course?



Data Literacy: Week 7 Survey

* 1. The video this week was helpful to me.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

* 2. I am satisfied with the amount of time it took me to complete course requirements this week.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

* 3. I am satisfied with my interactions with my course facilitator.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree
- ☐ Not Applicable

* 4. The Diigo Library of resources was helpful to me this week.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree
- ☐ Not Applicable

* 5. To what extent do you agree with the following statements with regards to participation this week's **module**: Participation in this week's **module** has:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
deepened my understanding of how to give my students opportunities to develop Data Literacy Skills.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
led to a change in how I plan units/lessons.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
improved my ability to include instructional strategies that promote Data Literacy in students.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- * 6. To what extent do you agree with the following statements with regards to participation this week's **discussion**: Participation in this week's **discussion** has:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
deepened my understanding of how to give my students opportunities to develop Data Literacy Skills.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
led to a change in how I plan units/lessons.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
improved my ability to include instructional strategies that promote Data Literacy in students.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

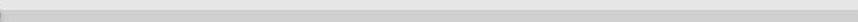
- * 7. To what degree can you include instructional strategies that enhance your students' opportunities to develop Data Literacy skills?

None Some A Great Deal

☐ 

- * 8. To what degree can you give students opportunities to engage with quantitative data as part of analytical tasks such as problem solving, investigation, and design?

None Some A Great Deal

☐ 

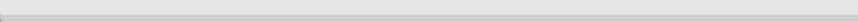
- * 9. To what degree can you give students opportunities to engage with qualitative data as part of analytical tasks such as problem solving, investigation, and design?

None Some A Great Deal

☐ 

- * 10. To what degree can you give students guidance for data-related activities?

None Some A Great Deal

☐ 

* 11. To what degree can you give students support with reasoning about data generation?

None Some A Great Deal



* 12. To what degree can you give students support with reasoning about data analysis?

None Some A Great Deal



* 13. To what degree can you give students support with reasoning about data representation?

None Some A Great Deal



* 14. To what degree can you give students support with reasoning about data Interpretation?

None Some A Great Deal



* 15. To what degree can you give students support determining appropriate and ethical uses of data?

None Some A Great Deal

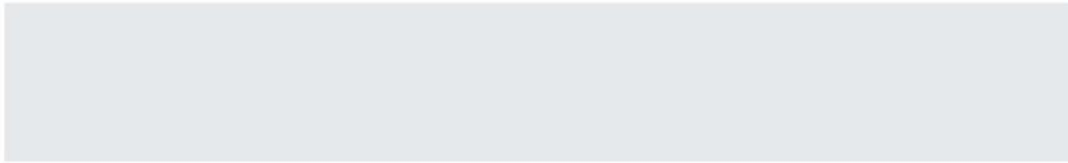


16. How has the discussion enhanced your experience in this course?



* 17. About how much time did you spend completing course requirements this week?

18. Do you have any recommendations on how to improve any aspect of your experience this week? Would you like to share feedback that was not directly asked in the questions above? Would you like to provide additional detail to any of your responses above?



* 1. The video this week was helpful to me.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

* 2. I am satisfied with the amount of time it took me to complete course requirements this week.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

* 3. I am satisfied with my interactions with my course facilitator.

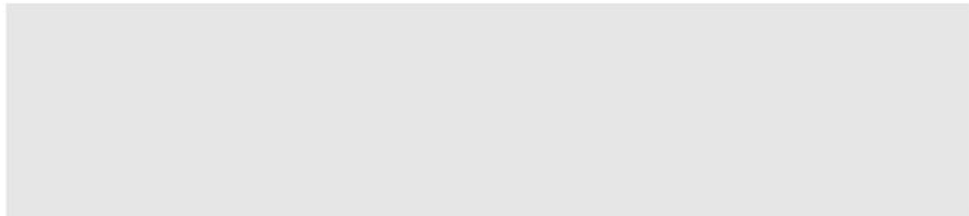
- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree
- ☐ Not Applicable

* 4. The Diigo Library of resources was helpful to me this week.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree
- ☐ Not Applicable

* 5. Were the instructions this week clear to you? (If you answer "No", please briefly explain what aspects were unclear.)

- ☐ Yes
- ☐ No



- * 6. To what extent do you agree with the following statements with regards to participation this week's **module**: Participation in this week's **module** has:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
deepened my understanding of how to give my students opportunities to develop Digital Literacy & Computer Science Skills.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
led to a change in how I plan units/lessons.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
improved my ability to include instructional strategies that promote Digital Literacy & Computer Science in students.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- * 7. To what extent do you agree with the following statements with regards to participation this week's **discussion**: Participation in this week's **discussion** has:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
deepened my understanding of how to give my students opportunities to develop Digital Literacy & Computer Science Skills.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
led to a change in how I plan units/lessons.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
improved my ability to include instructional strategies that promote Digital Literacy & Computer Science in students.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- * 8. To what degree can you include instructional strategies that enhance your students' opportunities to develop Digital Literacy & Computer Science skills?

None	Some	A Great Deal
<input type="radio"/>		

- * 9. To what degree can you integrate computer science concepts in your STEM content to support students' problem solving?

None Some A Great Deal



- * 10. To what degree can you integrate computer science concepts in your STEM content to support students' critical thinking?

None Some A Great Deal



- * 11. To what degree can you integrate computer science concepts in your STEM content to support students' logic-based reasoning?

None Some A Great Deal

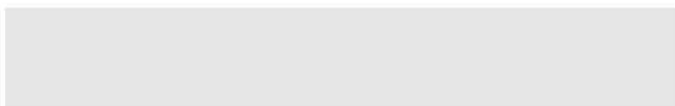


- * 12. To what degree can you support students with digital literacy skills needed to use computer tools?

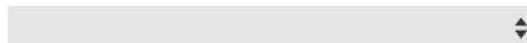
None Some A Great Deal



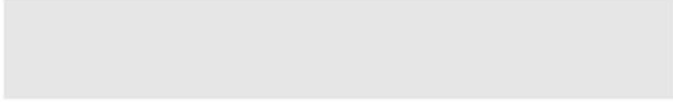
13. How has the discussion enhanced your experience in this course?



- * 14. About how much time did you spend completing course requirements this week?



15. Do you have any recommendations on how to improve any aspect of your experience this week? Would you like to share feedback that was not directly asked in the questions above? Would you like to provide additional detail to any of your responses above?





STEM Education in the 21st Century: Final Survey

Thank you for participating in STEM Education in the 21st Century!

Thank you for participating in our course and thank you for taking the time to complete this survey. Your feedback is important.

Throughout this online course, you explored 7 Essential Skills that are outlined in the STEM Education Framework. The Essential Skills are defined below. As you complete the survey, you can consider these definitions and your experience in the course.

Critical Thinking: The mental processes, strategies, and representations people use to solve problems, make decisions, and learn new concepts (Sternberg, 1985).

Problem Solving: Application of prior knowledge and skills (i.e., strategies) that allow persons to tackle a range of new tasks and situations within some performance domain (adapted from NRC 2012, *Education for Life and Work: Developing Transferable Knowledge and Skills in the 21st Century*, p. 167).

Creativity: Use of a wide range of idea creation techniques (such as brainstorming), generation and use of new and worthwhile ideas (both incremental and radical concepts), openness to new and diverse perspectives (adapted from Partnership for 21st Century Skills website materials).

Communication: Effectively using oral, written, and nonverbal communication skills for multiple purposes within diverse contexts (e.g., to inform, instruct, motivate, persuade, and share ideas). 21st century communication skills also include effective listening; using technology to communicate; and being able to evaluate the effectiveness of communication efforts adapted from Partnership for 21st Century Skills website materials.

Collaboration: “Coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem” (Roschelle and Teasley, 1995, p. 70) and/or “the activity of working together towards a common goal” (Hesse, Care, Buder, Sassenberg, et al., 2015, p. 38).

Data Literacy: Understanding, explaining, and documenting the utility and limitations of data by becoming a critical consumer of data, finding meaning in data, and taking appropriate action based on data, as well as an ability to identify,

collect, organize, evaluate, analyze, interpret, present, and protect data (adapted from: Building Global Interest in Data Literacy: A Dialogue-Workshop Report, as reported by Educational Design Center - May 4, 2016).

Digital Literacy & Computer Science: Ability to use information and a variety of communication technologies to find, evaluate, create, and communicate information and collaborate with peers, colleagues, family or the general public; including an understanding of ethics and privacy and computational skills (e.g., abstraction, algorithms, data, programming and development, modeling and simulation) (adapted from ALA Office for Information Technology Policy, ALA Digital Literacy Taskforce (2011)).



STEM Education in the 21st Century: Final Survey

* 1. To what degree do you think this course helped you improve your instructional unit?

None Some A Great Deal

* 2. To what degree do you think the weekly online discussions helped you improve your instructional unit?

None Some A Great Deal

- * 3. To what degree do you think this course improved your ability to develop instructional units where students have opportunities to improve their **critical thinking** skills?

None Some A Great Deal



- * 4. To what degree do you think this course improved your ability to develop instructional units where students have opportunities to improve their **problem solving** skills?

None Some A Great Deal



- * 5. To what degree do you think this course improved your ability to develop instructional units where students have opportunities to improve their **creativity** skills?

None Some A Great Deal



- * 6. To what degree do you think this course improved your ability to develop instructional units where students have opportunities to improve their **communication** skills?

None Some A Great Deal



- * 7. To what degree do you think this course improved your ability to develop instructional units where students have opportunities to improve their **collaboration** skills?

None Some A Great Deal



- * 8. To what degree do you think this course improved your ability to develop instructional units where students have opportunities to improve their data literacy skills?

None Some A Great Deal

- * 9. To what degree do you think this course improved your ability to develop instructional units where students have opportunities to improve their **digital literacy & computer science** skills?

None Some A Great Deal

- * 10. Using the STEM Education Framework would enhance my teaching effectiveness.**

[illegible]

- * 11. Using the STEM Education Framework would make it easier to plan learning experiences for my students.

[illegible]

- * 12. I would find the STEM Education Framework useful in my job.

[illegible]

- * 13. Learning to apply the STEM Education Framework to other instructional units would be easy for me.

[illegible]

* 14. It would be easy for me to become skillful at using the STEM Education Framework.

Extremely unlikely	Quite unlikely	Slightly unlikely	Neither likely nor unlikely	Slightly likely	Quite likely	Extremely likely
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* 15. I would find the STEM Education Framework easy to use.

Extremely unlikely	Quite unlikely	Slightly unlikely	Neither likely nor unlikely	Slightly likely	Quite likely	Extremely likely
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* 16. Thinking ahead to the **next 6 months**: How likely are you to incorporate each of the following Essential Skills in your instruction?

	Extremely likely	Somewhat likely	Neither likely nor unlikely	Somewhat unlikely	Extremely unlikely
Critical Thinking	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Problem Solving	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Creativity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Communication	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Collaboration	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Data Literacy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Digital Literacy & Computer Science	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* 17. Thinking ahead to the next 12 months: How likely are you to incorporate each of the following Essential Skills in your instruction?

	Extremely likely	Somewhat likely	Neither likely nor unlikely	Somewhat unlikely	Extremely unlikely
Critical Thinking	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Problem Solving	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Creativity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Communication	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Collaboration	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Data Literacy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Digital Literacy & Computer Science	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* 18. How would you describe this course to a colleague or administrator at your school?